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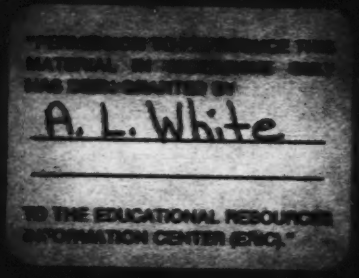
ABSTRACT

This publication contains 24 studies which focus on: the fostering of inquiry in secondary school science laboratories; realistic expectations for traditional laboratory work; a content-based, college-level science course for all students; understanding learning at the classroom level; transitions and student task involvement; a project to encourage metacognitive behavior; cognitive variables in problem-solving in chemistry; health attitudes and health awareness in high school students; students' perceptions of stress; attitude and knowledge of Tasmanian secondary students toward energy conservation and environment; students' intentions to study or not to study science (using Ajzen and Fishbein's theory of reasoned action) and a possible paradigm shift for science education. Other studies involve such areas as the importance of context in educational research; use of concept maps in assessing a computer-based biology activity; children's ideas about temperature and electric current; learners' response to the idea of environment; the long-term kinetics of conceptual development; circular motion concepts of first-year engineering students; teachers' concepts in science; effect of training in concept mapping on student achievement in traditional classroom tests; Australian general science; predicting tertiary academic performance in terms of student cognitive and non-cognitive variables; and the analysis of science curricula in Australia. (JN)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IN

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A TRIBUTE

On June 11th, 1985 Science Education Research suffered a severe loss when Roger Osborne was killed in an accident near his home in Hamilton, New Zealand. Roger was a staunch supporter of the Australian Science Education Research Association from the first meeting he attended at Wagga Wagga in 1977. Evidence of his interest and activity in science education research are to be found in Volumes 7 to 14 in Research in Science Education. His studies of understanding of science had a major influence on the style of research undertaken in Australia and New Zealand. He will be sadly missed in both countries, not only for the stimulation he gave to our work, but also for his cheerfulness and enthusiasm. He encouraged us all.

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PREFACE

Concept mapping still appears to be a predominant activity among science educators in Australia. In this issue of Research in Science Education, Appleton, for example, adds to the body of knowledge about children's ideas associated with temperature and Butts reports on children's understanding of electric current. Searle complements information in previous issues of RISE by detailing first year engineering students' concepts of circular motion, Fensham and Johnson tell us about learners' ideas of environment, and Ameh and Gunstone focus on teachers' concepts in science.

The characteristics of learners have also interested researchers. Kam-Wah Lee considers six cognitive variables that are associated with pupils' problem solving in electro-chemistry at HSC level, Maddock reports on students' awareness of and attitudes to health and Garrard and Brumby on their perceptions of stress. Fearn-Wannon also focuses on characteristics but uses cognitive and noncognitive variables to predict academic performance. Other papers, those by Walsh and Lynch, Northfield and Gunstone, Butler and Beasley, and Mitchell and Baird address teacher training and teaching issues. The Walsh and Lynch paper is a follow-on from a 1984 RISE paper describing the introduction of a compulsory science subject into first year primary teacher training in Tasmania. The 1985 paper considers the perceptions of science and science teaching held by those students who elected to continue with a study of science. The Northfield and Gunstone paper, on the other hand, describes the authors' experiences in a secondary classroom and their attempts to implement their understanding of learning. They conclude that that understanding has been modified by their experiences and that, in particular, the effects of peer group interactions in the classroom have been under-estimated as a factor in the learning environment.

Two papers by Saowalak et al and Newman address issues associated with the role of laboratory work in science education, and Rosier reports on an IEA study using data about science curricula in Australia. Fawns presents an historical perspective on general science in Australia, White directs attention to the importance of context in educational research, while Edwards, in an embyronic paper, attempts to assess the domination that Newtonian Physics and the Cartesian belief in the certainty of knowledge have had on our belief systems. The impact on science teaching is also discussed with particular reference to the writings of Capra.

Further details about some completed projects, and studies under way, are provided in the research notes. There are details about teachers as researchers, probing understanding of environmental concepts using visual stimuli, the quality of learning outcomes, and a school developed science programme for poor readers and children's understanding of inheritance.

Richard P. Tisher

Editor

Research in Science Education, 1985, 15.

FOSTERING INQUIRY IN SECONDARY SCHOOL SCIENCE LABORATORIES

Bangorn Saowalak, William Butts and Christine Deer

THE ESSENCE OF SCIENTIFIC INQUIRY

A survey of the literature indicates that there is a wide range of conceptualisations of the term "scientific inquiry". Although scientific inquiry has been described as perhaps the most critical kind of activity that the scientist engages in, and for that reason represents one of the most important objectives of science education (Gagne 1963, p.144), there has been no consistency of the explanation of scientific inquiry in science education and its research literature. Scientific inquiry has been conceptualised as a stable process, as a fluid process and as problem solving.

Scientific inquiry, both as a stable process and as a fluid process, is concurrently practised by scientists in the scientific community. Scientific inquiry has become a widely accepted goal of all the new science curricula in Western countries (Yager 1976) and in Thailand (Sapianchai and Aylward 1977), as well as other developing countries (Baez 1976). It is argued here that to understand the kind of work that scientists engage in and how science arrives at its findings, students must be placed in the laboratory where they can have hands-on experience in experimenting and solving apparent problems appropriate to them. Student participation in scientific inquiry in the actual collection of data and analysis of real phenomena is an essential component of the inquiry curriculum (Schwab 1960). The laboratory will therefore be a place where students can develop an understanding that scientific knowledge is tentative, that science is not a process of proof or verification, but rather a process of disclosing events in nature.

INVESTIGATING SCIENTIFIC INQUIRY IN THE LABORATORY

An economical and useful approach for investigating how laboratories are used is

to analyse laboratory manuals for the nature of experiments presented to the students. Data from the analyses can provide teachers and/or curriculum developers with an overall picture of the nature of laboratory activities presented to students. And from these data, they can see whether or not the actual materials presented are congruent with the important goal of laboratory work, i.e., to involve the students in the processes of scientific inquiry.

There are a few instruments designed specifically to test the quality of written laboratory manuals (Shulman and Tamir 1973). Tamir and Lunetta (1978) developed an instrument called The Laboratory Structure and Task Analysis Inventory (LAI) for the purpose of analysing printed laboratory activities required of students in biological science curricula. The latest version of the instrument, including instructions for users, category definitions, and examples, is available in a 1978 report by Fuhrman, Lunetta, Novick and Tamir. The use of the LAI has been to analyse modern science curricula including all science disciplines, namely, Biology, Physics, and Chemistry. The analyses of numerous laboratory handbooks in the studies provide evidence that students are commonly asked to make observations and measurements, record results, manipulate apparatus, and draw conclusions. On the other hand, they are given few opportunities to formulate hypotheses and propose ways to test them, or to design and then actually perform an experiment. Yet, from these analyses it is obvious that in the development of experiential awareness of scientific inquiry, the laboratory activities examined do not live up to important goals of science education.

As stated goals of new science curricula in Thailand (Sapianchai and Aylward 1977) are similar to those described for new science curricula in Western countries, it was therefore the interest of the chief author to investigate the nature of laboratory exercises presented in new Thai science curricula, to see whether or not they are congruent with the stated goals. It is worth noting that in the new science curricula developed at the Institute for the Promotion of Teaching Science and Technology (IPST), Bangkok, laboratory activities are incorporated into the students' texts in all science curricula developed for both non-science students and those who follow the academic study of science disciplines.

AN INSTRUMENT TO MEASURE LABORATORY EXERCISES

The LAI instrument has two primary sections, namely, Organizational Categories

and Task Categories. The Organizational Categories provide an overview of the structure and approach of a laboratory investigation. The Task Categories specify all possible inquiry tasks the student could do in the laboratory investigation, ranging from planning and design through to applications of the experiment. The details of some of the categories are given in Table 1. Overall, the instrument yields a quantitative picture of the kinds of activities required of the student in performing laboratory investigations. It allows an "inquiry level" to be calculated.

If laboratory activities are at a "high" level of inquiry, instructions in laboratory manuals should be such that they allow students to engage in many or all of the above tasks, especially in: planning and design; student-initiated performance; higher-order interpretation; and application, which are the high-order inquiry skills. Laboratory work is at a "low" level of inquiry if laboratory instructions merely direct students to carry out the usual laboratory performance (text-directed performance and lower-order analysis), without requiring the independence of the students' judgement.

ANALYSIS AND RESULTS

Two textbooks for a high school science curriculum from Thailand and two from Australia were selected for the analyses of the nature of the laboratory work in these science curricula.

The analyses involved all the experiments (9 and 12 respectively) in the Thai science textbooks, World of Carbon and Energy and Everyday Life. Also, the first four experiments in the Australian laboratory manuals for Chemical Science (Carswell, 1980) and Biological Science: The Web of Life (Australian Academy of Science, 1981), and another six randomly-selected experiments in each of the manuals, were coded. Every experiment mentioned was coded using a modified version of the LAI.

Each of the laboratory experiments was coded in every category, both in the Organizational Categories and Task Categories, with either a plus sign (+) or a minus sign (-).

To check the reliability of the codings of the chief author, the Web of Life and Chemical Science manuals were also coded by eight science teachers using the LAI. Also, four science teachers who use or haved used the Chemical Science laboratory

manual coded half the number of the laboratory experiments. The other four science teachers who use or have used the Web of Life laboratory manual coded half the number of the laboratory experiments. These codings yielded an acceptable quantitative measure of the reliability of the modified LAI used in this study.

In the analyses, no attempt has been made to compare Thai and Australian science curricula. However, for convenience, data from the Thai and Australian science curricula are discussed simultaneously.

The Laboratory Task Analysis in Table 1 indicates that in both World of Carbon and Energy and Everyday Life, students are generally asked to perform observation, measurement, apparatus manipulation, reporting procedures, and interpretation of relationships in their experiments.

However, they are not required to use higher-order skills of scientific inquiry, for example, to formulate hypotheses to be tested, to design measurement procedure or experiment, to explain or discuss variables or assumptions that underlie the experiment, or to predict, based upon results of the experiment.

The summary of Laboratory Task Analysis of Chemical Science and Web of Life experiments shows that students are required to perform observation, measurement, apparatus manipulation, reporting procedures and interpretation of data or conclusion. However, in the two Australian laboratory manuals there are a number of experiments directing students to perform higher-order inquiry skills, expecially in the Web of Life experiments, as shown in Table 1. In fact, overall, the data in Table 1 reveal that Web of Life laboratory manual instructions call for more higher-order inquiry skills than those of Chemical Science.

CONCLUSIONS AND IMPLICATIONS

"Scientific Inquiry" is one of the important goals of science education, and certainly, therefore, of laboratory work, either in a developed country or in a developing country like Thailand.

TABLE 1

SUMMARY OF SOME LABORATORY TASK ANALYSIS
(THAI SCIENCE CURRICULUM AND AUSTRALIAN SCIENCE CURRICULUM)

Task Categories	Number of Experiments			
	World of Carbon	Energy and Everyday Life	Chemical Science	Web of Life
Total number of experiments analysed	9	12	17	10
1. Planning & Design				
1.3 Formulates hypothesis to be tested	0	0	4	2
1.4 Designs observation or measurement procedure	0	0	5	4
2. Performance				
2.1a Carries out qualitative observation	9	12	17	10
2.1b Carries out quantitative observation or measurement	1	7	13	5
2.2 Manipulates apparatus, develops technique	4	5	17	5
2.3 Records result, describes observation	9	12	17	10
2.5 Interprets or explains experimental technique	2	1	5	4
3. Analysis & Interpretation				
3.4 Explains relationship	6	8	8	10
3.5 Identifies/explains or discusses variables, limitations and/or assumptions that underlie the experiment	0	0	1	5
3.6 Formulates or proposes a generalisation or model	0	0	4	6
4. Application				
4.1 Predicts based upon results of this investigation	1	0	0	2
4.3 Applies experimental technique to new problem or variable	0	0	6	3

There are several ways to help students understand the nature of scientific inquiry. However, the laboratory is obviously the place where students can have a direct, hands-on experience in actually carrying out the processes of scientific inquiry by themselves, with appropriate guidance from the teacher. Clearly, student participation in scientific inquiry in the actual collection of data and analysis of real phenomena in the laboratory is essential in every modern science curriculum.

This paper has reported an investigation of selected laboratory manuals and explored the nature of laboratory exercises presented to students. From this investigation the conclusions and implications drawn are:-

1. The LAI instrument can be used to identify specific strengths and deficiencies of curricula in their specification of laboratory organisation and tasks. It is a very useful instrument for determining the practical nature of the curriculum, particularly the nature of the laboratory work presented to students.

2. The LAI provides a basis for the assessment of goals regarding student development of inquiry skills.

3. The modified version of the LAI used in this project can be used successfully by untrained users.

4. The analyses in this project have identified some discrepancies between the stated goals for laboratory work and the instructions found in the laboratory experiments, that are worthy of serious consideration. The discrepancies in the two Thai textbooks analysed are: no opportunity is provided at all in the laboratory instructions for higher level inquiry skills, such as, hypothesising and testing hypotheses, or designing experiments and actually performing them.

   The data from the analyses of the two Australian laboratory manuals reveal that only limited opportunites are provided in Chemical Science for the higher level inquiry skills. The Web of Life experiments, however, exhibit a trend in the development of the higher level inquiry skills. Students using Web of Life have an opportunity to formulate and test hypotheses.

5. Data from the analyses of the experiments in the Thai textbooks should provide the science curriculum developers in Thailand with information about the

production of science materials, particularly the writing of laboratory experiment instructions in a way relevant to their goals.

6. Until the deficiencies revealed from the analyses reported in this paper have been corrected, the full potential of laboratory work in secondary school science will not be achieved. Furthermore the student could acquire a rather twisted view of the world of science. It is noteworthy that the problems of the nature of the experiments identified, either in the Thai or Australian science curricula, can be remedied by concerned and knowledgeable teachers. Teachers who recognise the importance of helping students to develop the scientific inquiry skills can, of course, find ways to increase the student behaviours that are not provided for in the instructions in the laboratory manuals. It is to be hoped that this does occur in practice.

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REALISTIC EXPECTATIONS FOR TRADITIONAL LABORATORY WORK

Barry Newman

INTRODUCTION

Laboratory work is generally regarded as a necessary and highly significant component of the science education experience provided for secondary school students. In what follows some attention is paid to the high esteem in which it is held, a brief analysis of the nature of traditional laboratory activity is provided and a number of problems associated with such activity are outlined. It is then argued that traditional laboratory work is unable to achieve much normally expected of it. Certain alternatives to traditional laboratory activity are regarded as more satisfactory in this connection and the paper concludes with a plea for realism and responsibility.

There is little question that laboratory work is widely accepted as being of considerable value. One has only to look at the lists of objectives associated with laboratory work that are put forward to science education or proposed for research purposes (e.g., see Anderson, 1976; Beatty and Woolnough, 1982) to realise that people have high hopes for science practical activitites. Such objectives relate to much of what science teachers probably want to do in science education as a whole.

TRADITIONAL LABORATORY ACTIVITY

It is not uncommon in articles on laboratory work to refer to it as though the reader would readily understand what the writer has in mind. What is in fact envisaged is a somewhat standard picture of laboratory activity. There are of course variations on the pattern but traditional laboratory work can be described as follows:

> After a brief introduction by the teacher explaining what has to be done and how it has to be done, the student operates upon some materials and equipment to

bring about some transformation of the same. The student may then have to process certain data available before, during and after the transformation process, ordering it, treating it mathematically etc. During the hands-on activity and/or at its conclusion the student is prompted to communicate ideas related to the activity with other students and perhaps the teacher, and is often required to commit some material to writing. At the conclusion of the activity the teacher works with the class as a whole, attempting to have the students think about what has been done, what has been observed, calculated etc. and its significance.

One of the common aims associated with traditional laboratory work is to assist students to develop an understanding of the 'facts', concepts, principles and theories of science.

PROBLEMS ASSOCIATED WITH TRADITIONAL LABORATORY WORK

It has been argued elsewhere (Newman, 1981) that traditional laboratory work, is thwart with difficulties: e.g.,

1. There are many factors that can be brought to bear upon the student with his/her understandings, capabilities and attitudes - fellow students, the teacher, the textual material, the physical learning environment, equipment and materials, data processing, the processed data, the formal communication process and the communicated material. There are so many factors that the possiblility of something amiss leading to an aim no being realised is high.

2. Problems occur. Who has not witnessed the dissection of the left ventricle rather than the right; an ammeter, but not the voltmeter reading zero; the 'north-seeking' pole of the compass needle pointing south?

3 Information necessary for understanding the principle to be learnt is not available. For example, a student who has to learn about relative ionic mobilities is not told that the molarities of all solutions are equal. He/she was expected to realise that different fractions from a distillation had different boiling ranges when no thermometer had been used for fear of breakage.

4. Some exercises, contrary to the intention of the teacher, give misinformation. The powdered magnesium took longer to react with the acid than the same mass of magnesium strip. The aqueous humour of the sheep's eye was filled with black specks.

5. Traditional laboratory exercises involve the student in considerable manipulative activity and is accompanied by data processing and writing. Given the extent to which these matters dominate the 'hands-on' activity, it is unlikely that many students have much time to think about what it all means.

WHAT TRADITIONAL LABORATORY WORK IS UNABLE TO DO

Given the nature of traditional laboratory work;

- It is unlikely that many 'facts', concepts, principles and theories of science will be acquired directly.
- It is not geared to provide an understanding of the nature of scientific 'facts', etc.
- If students are to learn cognitive processing skills then it is a very poor tool.
- It might give the misleading impression that most knowlege and understanding can properly be gained through laboratory work, and that skills simply can't be learnt for there's never enough time to practice or that they're too elusive to determine their features.

Of course traditional laboratory work or any laboratory work may make significant contributions in other areas - in developing interpersonal relationships for example, or in helping students to have a more positive (or less negative) attitude towards school science. Yet it is unlikely that educators would argue on these grounds alone that laboratory activities should occupy a prominent place in science education.

ALTERNATIVES TO TRADITIONAL LABORATORY WORK

If the conventional type of laboratory work is singularly so unsatisfactory other alternatives have to be sought. Two general types are available: highly structured, unconventional laboratory work, and laboratory work which is not laboratory work!

(a) Highly Structured Unconventional Laboratory Work

In highly structured unconventional laboratory work the laboratory is geared towards the attainment of clearly specified goals. One method is that described in Novak's "Learning How to Learn Program" (1980). In his scheme the student's

attention is upon the identification and characterisation of suitable 'focus' questions and objects/events that are central to an inquiry.

Another scheme is that involving Karplus' 'Learning Cycle' (1977). There are three phases of learning to the cycle: exploration, concept introduction and concept application with laboratory activity playing a significant part in the first and last phases.

Whether any of these methodologies will, more so than conventional laboratory activity, lead to the attainment of goals for science education is an open question. What each has in its favour is its highly specific orientation.

(b) Laboratory Work which is NOT Laboratory Work

The second general type of alternative is one where the laboratory exercise is out of the pupil's control. It could be that no real laboratory exercise is performed.

The teacher demonstration, the filmed experiment (for an example see Ben-Zvi et al., 1976) and the computer simulated experiment (see Moore and Thomas, 1983) are three examples of this type. Presumably, the exercise would proceed as anticipated.

Whether any of these methodologies will be successful is uncertain, but there are at least three things in their favour. The chances of the exercise not going according to plan are minimal, misleading characteristics can be dealt with and the time required is normally less than that for student controlled laboratory work.

A PLEA FOR REALISM AND RESPONSIBILITY

At the heart of this paper is a plea for realism and responsibility. Conventional laboratory activities do little more than maintain or develop a positive attitude towards school science, and as a-not-insignificant-consequence, encourage some science students to pursue further studies in science.

Highly structured, unconventional laboratory work, with it high specificity, might well bring about the acquisition of skills needed for scientific practice, the acquisition

of knowledge and understanding of the nature of scientific practice, and awareness of some affective characteristics associated with scientific practice as well as the acquisition of some of those characteristics. It can also be used to teach the 'facts', concepts, etc. of science but, as with traditional laboratory work, one should not have high expectations of accomplishing a great deal in the time available.

Laboratory work that is not laboratory work involves a very different approach. One might expect to teach more of the 'facts' etc. of science than with the student-centred laboratory activities. Students might acquire cognitive skills through this methodology though it is highly unlikely they would best acquire psychomotor skills through such an approach. Students can acquire a knowledge and understanding of the nature of scientific practice but are unlikely to develop significant affective characteristics helpful for scientific practice.

A more realistic and responsible approach to laboratory work means using a variety of methodologies while recognising that some will do a better job than others, and that, for different students and different goals, different mixes of methodologies are more appropriate. Laboratory work has its place, but it deserves a more thoughtful place than is traditionally the case.

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EDUCATING RITA: PART 2.
ANYMORE FOR SCIENCE, AND IF SO, WHY?
AN EVALUATION REPORT

Max Walsh and Paddy Lynch

INTRODUCTION

The general lack of science in primary schools in most English speaking countries has been well documented in the literature over the past decade. This gloomy picture has persisted despite the abundance of science curriculum materials of all types which are widely available and which are, in fact, familiar to teachers. We recognised that the answer to the problem has more to do with the level of scientific knowledge of the teachers, and in 1984 we offered a very substantial content-based science course for ALL students enrolling in the first year of the Bachelor of Education degree in the University of Tasmania.

The course was the Open University S101 Science: A Foundation Course, a mulit-disciplinary, self-paced program designed for distance learning but offered in our institution to attending students.

The range of methodological problems which occurred as a result of our decision to implement the course has been described previously (Walsh, Lynch, Jones & Kerrison, 1984). This paper examines some performance and attitudinal data for those students who opted to continue studying science into Year 2 (1985), given that the first year of the course had been significantly more demanding than anything offered previously as part of our teacher training program. This latter point is quite significant; in previous years only a select group had chosen to study science in Year 1 et seq. Under our new arrangement, all students who subsequently graduate as teachers will have had, as a minimum, a quite substantial core course in science, a number which is an order of magnitude greater than our previous select few students who have studied science. This point will be discussed again later.

SOME DATA ABOUT THE 1984 INTAKE

In 1984, 832 students presented for assessment at the end of the year. Of these students, 67% were female; 13% had studied 3 or more Higher School Certificate (H.S.C.) science subjects; 28% had studied H.S.C. biology only; 37% had not studied any science beyond Grade 10 and 11% had not studied H.S.C at all.

The final end of year results for this group were as follows: Distinction: 7 (8%), Credit: 9 (11%), Pass: 57 (69%), Fail: 10 (12%).

Of those who passed 22/73 (30%) students opted to continue with Science into Year 2 in 1985. Of these 22 students, 5 had gained a Distinction in 1984, 3 a Credit, and 14 were awarded a Pass. We were interested to know what factors had influenced them to choose Science as their major academic study, since they would be compelled to study Science in Years 3 and 4 as a consequence of their decision. The fact that such a large number of students are continuing in Science represents a very significant change from previous years.

It also represents a very large shift in the number of science specialists who will graduate into the teaching service in 1968. This report describes the perceptions held by the current students majoring in science.

RESULTS AND DISCUSSION

Each of the 22 students were interviewed separately using a structured format. A key question was asked, and several "prompts" were used when necessary to elicit further information.

The interview protocol was as follows :

1. What is your science background?
   at H.S.C.?
   at School Certificate?

2. What do you understand by the word "SCIENCE"?

3. Have you any thoughts at this stage about how you will teach Science? (Prompts = methods, content)

4. Were your perceptions about what Science and Science teaching were about in any way changed by the Year 1 Science course you studied last year?

5. How did the Year 1 course affect your KNOWLEDGE of Science? (Prompts = overall, specific areas)

6. How did the Year 1 course affect your ATTITUDE to Science? (Prompts = confidence, like/dislike, affect a change in direction on your part)

7. What were your reasons for continuing in the Science area? Give the most important one. (Prompts = restricted choice in Year 2, job opportunities, peer group influence, staff)

The first three questions were designed as "ice-breakers" to relax students before we moved to the questions most pertinent to our study. The response to Question 1 yielded data on the composition of the group: 9/22 (41%) had studied 2 or more H.S.C. science subjects; 6/22 (27%) had studied H.S.C. Biology only; and 7/22 (32%) had not studies science beyong Grade 10. It is interesting to note that we attracted virtually all students who had a Science-based school background, something not achieved with any of our previous courses. Of the 7 students who had not studied science at H.S.C. at all, 4 had not been at school for 8 years or more and 2 of them had not attempted H.S.C.

Question 3, thoughts about teaching science, yielded some interesting data; 16/22 (73%) stressed that a practical "hands-on" approach would take precedence. Whether the other 27% had no particular orientation at this stage. These comments contrasted with opinions expressed earlier when we implemented the O.U. course. Then students said they would adopt the "text-book" approach and would not give much attention to practical work as an integral part of science.

Question 4, on changes in perceptions of science are science teaching yielded a range of responses. Some students indicated that the course had clarified many concepts about which they had only vague or incomplete notions from their schooling.

In response to question 5, ten student's claimed their knowledge had increased significantly whereas only six maintained there had been no change.

In question 6, attitude to science, 82% (18) reported a positive effect, 4.5% (1) a negative effect and 13.5% (3) no change. Two examples of positive responses follow:

> "From high school I really began to dislike science. I had a bad teacher, but last year I began to really enjoy science and so I want to continue with it because it interests me."
>
> Lee-anne, 19 year old.

> "For sure. I left shool such a long time ago and it was a subject which scared me but I'm not scared anymore. I haven't got the attitude now. I realise that it can be dealt with at my level, any level, and it is possible to explore it and learn from it but it need not be a mystery. I found that I could relate to that course last year."
>
> Judy, mature age re-entry student.

The final question, "Reasons for continuing with Science", yielded very interesting results.

None of the 22 students considered that restricted choice, friendship (peer groups) or staff members had influenced their choice. Seventeen (77%) gave increase confidence and renewed interest as the major influence, four (18%) felt that the relevance of science to young children had exerted most influence, and only one student said that he opted for Science because he thought his job prospects would be better.

The overall response of the Year 2 students to the experiences of the Year 1 course was very pleasing to us. It clearly has something to offer for the student who has a strong school background in Science as well as for the student who has not had the benefit of a worthwhile science education. It was also very pleasing to discover that even though the major part of the assigned work is given via the printed reader, students still perceived science as being activity-based, and were most impressed by the practical activities which were demanded of them. (Moon-watch, Fresh-water biology project, Chemistry experiments and the Geology excursions.)

We have been made aware that they have a weak appreciation of how they might teach Science, i.e. how they might translate this newly acquired knowledge into the elementary classroom. We see this as a new challenge for our year 2, 3 and 4 Curriculum Studies courses. Hopefully, the experience gained through the intensive Year 1 course will help students venture into more activity-based science whilst engaged in practice teaching. This will, in turn, lead to more science in the elementary school, which can only be a good thing.

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UNDERSTANDING LEARNING AT THE CLASSROOM LEVEL

Jeff Northfield and Richard Gunstone

During 1984 the authors were given the opportunity to teach a Year 7 science class at a local high school. After several years of involvement in science education at the tertiary level we felt we had developed an understanding of ideas and concepts related to metacognition and action research, student views of the world. We had shaped and taught these ideas to science teachers at preservice and inservice levels. Papers had been written for journals and discussed at conferences. Our commitment to and understanding of these ideas lead to expect that they might be implemented with some value and success in the classroom.

The experience of one year with a junior secondary class has proved both salutary and confusing. Our understanding of various concepts related to learning and teacher development proved to be limited when they were tested in the classroom. Describing and analysing the teaching experience has been difficult and has led to a review of our ideas of teaching and learning.

THE CONTEXT OF THE STUDY

The two authors were given responsibility for a Year 7 science class at a high school. Because other job commitments had to be completed we felt that if the school allotment was to be fulfilled two people should be involved. Throughout the year both of us attended 90 per cent of the classes and on only one occasion did the school have to arrange a replacement.

The curriculum content to be covered was listed as a series of topics which the science staff at the school had developed as part of a four year program. We were free to present the topics in any way, but had to keep to that content.

The 25 students covered a wide range of abilities and interests. There was for instance one student who could not read and another student who was either absent or at least half an hour late for 60 per cent of the classes. The three lessons per week were organized as a single period (50 minutes) and a double period (100 minutes).

We wanted to use some recently developed ideas about learning in science in an actual classroom. Some key features of these ideas about learning include:

- students have developed personal explanations of scientific phenomena which are persistent and provide critical conceptual frameworks for any learning which occurs (Osborne, 1980).
- students should have opportunities to gain personal understanding of concepts with activities that relate to existing ideas.
- students can be assisted to become more aware and gain greater control of their own learning (Baird & White, 1982).

We expected our teaching strategies to differ from the approaches the students would experience in their other classes. The purpose of the effort was therefore essentially to study responses to an implementation of these ideas of learning in the context of a high school classroom.

LEVELS OF UNDERSTANDING AS A FRAMEWORK FOR THE REVIEW

White (1984) outlines a meaning of the term 'understanding' which is useful in reviewing one year in the classroom. In summary we were taking ideas about which we had some understanding in order to gain greater understanding of a different type. White argues that understanding 'is applied to a range of different targets which differ in nature and scale'. He proposes six targets of understanding: concepts, whole disciplines, single elements of knowledge, extensive communications, situations, and people.

Although not derived as a basis for analysing teaching and learning of school science, these six aspects of understanding provide a useful starting point for reviewing our teaching experience. The authors had agreed to follow the Year 7 science program outlined in the form of topic headings. It was in the teaching approach that we were most keen to implement ideas: learning is an active process which should begin with

the experience of the child. We judged it important to have students discuss experiences and their explanations for natural phenomena. We introduced a 'Thinking Book' as a way of encouraging students to write down personal views and explanations as new topics were introduced. These student views were not 'correct or incorrect' and any revision of views was to be a personal decision. It was emphasized that student ideas of the topic were important for learning. In terms of White's targets we could say that we began the year with a reasonable understanding of three targets and were trying to improve our understanding in the other three areas. Our rationale for the way science learning should occur can be classed as understanding of concepts (concepts of metacognition, student views of the world, etc). Our knowledge of topics to be taught together with teaching skills developed from more than 20 years' experience can be seen as an understanding of single elements or knowledge. Our long involvement in science curriculum and teaching issues allowed us to be confident in our understanding of the whole discipline of science education. What we were less confident about were our understandings of the other targets, extensive communication, situations, and people. The teaching venture can therefore be seen as an attempt to increase understanding of teaching and learning of science in these remaining three areas. Some of the results of the experience will be described using these areas as headings.

UNDERSTANDING OF EXTENSIVE COMMUNICATIONS

In developing this target of understanding White (1984) emphasizes a form of understanding which seems to be related to the process of implementation. What happens when the ideas are put into practice? In some ways this is analogous to the teacher gaining personal meaning when using a set of curriculum resources in the classroom. The notion of teacher as researcher is an expression conveying a need to regard teaching as a form of experiment with curriculum ideas. The curriculum gains meaning for each teacher in each situtation and a form of understanding develops if one is prepared to take a 'research stance' to teaching.

In this case the ideas of learning were tested in the classroom with the following observations contributing to our understanding.

a) Thinking is an uncomfortable experience for many students. When a basic tenet of the learning approach is that students should be encouraged to be active in learning it is a sobering experience to be told, as we were, in a friendly manner 'Science

is all right ... except when we have to think'. When given a range of activities most students tended to choose tasks which appeared to require a straightforward response from a book. What can be done to make schools and classrooms places where thinking is an enjoyable activity? There appear to be risks and uncertainty associated with thinking. Their ideas may be 'worthless' or, even worse, 'incorrect'. Even after one year many students lacked confidence to propose ideas although the 'safety' of the Thinking Book and the regular requirement to provide personal responses appeared to encourage some development in this area.

b) What is 'real science'? The emphasis on science in the home and everday life though tolerated by students was not seen as 'real science'. Year 7 students anticipate using the apparatus they have heard about and seen in science rooms. Using the equipment becomes an important end in itself, using it for any purpose is not important. Science does not occur in everyday life and this group of Year 7 students already associated science with a form of school science. Applying science concepts to everyday experience was something very few students could do without specific prompting, an observation which many teachers support, in our experience.

Beginning with student 'views of the world' and basing teaching and learning on this starting point was an uncomfortable approach for students. Science was seen as a subject which had answers and there was some frustration with teachers who tended to respond to questions with further questions rather than give direct answers.

c) The Thinking Book - 'a place where you can't be wrong'. Student reaction to the Thinking Book varied from 'another strange requirement' to a place where ideas were expressed that could not be wrong. The students who referred to its contents as 'commonsense' probably understood the purpose and many students appreciated that their views were considered important. Box 1 sets out some student reactions in the Thinking Book and gives some idea of how this technique contributed to their ideas about science. The use of the Thinking Book placed us in a dilemma. Students valued the book as a place to write their own views and explanations with no fear of evaluation from teachers and peers. Yet these ideas can be very important for teachers planning each topic as they reveal experiences, interests, and misconceptions which can shape learning activities. Although we wanted to read the books frequently we were concerned that this might inhibit students responses.

BOX 1

STUDENT REACTIONS TO THE THINKING BOOK (19 respondents)

Why do you think we had a Thinking Book in Science this year?

- 'give our ideas'. (10 responses)
- 'help teachers understand our thinking/feeling'. (6 responses)
- 'pretest'. (1 response)
- 'we could think more'. (1 response)
- 'to bore us'. (1 response)

Did you enjoy having a Thinking Book?

Yes/No. Can you give some reasons?

Yes: 15
- 'could write wrong answers and be write (sic)'. (Student No. 1)
- 'hard to express some things to the whole class'. (2)
- 'helped me understand'. (3)
- 'express our feelings'. (4)
- 'can put down our ideas'. (7)
- 'have to think and write'. (8)
- 'was good'. (9)
- 'could be untidy, no pressure for answer'. (10)
- 'could write what we thought and still be correct'. (12)
- 'give our own ideas'. (13)
- 'never wrong really'. (14)
- 'can think what you like'. (15)
- 'can write what you want and doesn't have to be true'. (19)
- 'no reason'. (6)

No: 4
- 'boring, not learning anything'. (5)
- 'boring'. (16), (18)
- 'no reason'. (17)

UNDERSTANDING OF SITUATIONS

This target refers to the development of understanding of a complex set of events, in the case, the classroom. The effect of the introduction of the learning/teaching approach on the dynamics of the classroom was most marked in two respects. In both cases there is literature to support and interpret observations that we made during the year.

a) Managing the class: a major teacher priority. There are times when managing a group of 25 students requires a firm response to one or more incidents in the classroom. The way our schools are organized and the expectations for teachers require a high priority to be placed on management. Unfortunately there were times when management was restored to the detriment of the learning environment. It appeared as if there were a 'ripple effect' (Kounin, 1970) which affected the learning conditions. Students seemed reluctant to contribute, perhaps due to resentment in some cases or disappointment with the situation in others. On three occasions the effects extended into the following lesson. The learning environment we were trying to maintain proved to be quite fragile, perhaps related to an unusual approach to learning being developed in science when compared to their other subjects.

b) Assessment and grading requirements. Some form of assessment is an essential part of the schooling process and there is a challenge to develop assessment procedures which are compatible with the learning expectations. An emphasis on rote recall of facts would be clearly inappropriate. On the other hand, ways of assessing student effort and involvement in the learning process are difficult to develop and tend to be very subjective. On two occasions in the latter part of the year students were invited to provide a mark for their effort and involvement in learning tasks. Only one student declined the invitation and there was no cause to query any of the submitted marks which were all included in the continuous assessment record. Several students also added written comments explaining their mark and giving frank assessments of strengths and weaknesses in their performance.

Assessment procedures such as concept maps and Venn diagrams which are seen as compatible with the learning approach were not used extensively with this group of students. Some initial introductions to these techniques resulted in some confusion for students and time was not spent on their use. Our limited experience suggests that

students would be able to use the techniquest at Year 7 level only after a considerable amount of training time and effort.

Testing and management control situations have the potential for disturbing the learning setting we were trying to establish. In both situations what is normally done is incompatible with a teaching learning approach which emphasises student conceptions and activity.

UNDERSTANDING OF PEOPLE

The opportunity to teach the Year 7 class contributed greatly to our understanding of students as they respond to teaching and learning in science. The teaching learning approach being followed highlighted the individual differences between students. The approach can be considered as an active search for these differences as the basis for the learning activities which may follow. The differences in students that are exposed can become very alarming for the teaching who has to respond. Differences in background experiences, explanatory conceptions, and interests become the raw material for presenting the topic and, when linked to differences in student abilities, the teaching task is daunting. Students can feel cheated if their ideas and interests which have been sought by the teaching are then ignored in the following lessons. There were also individual differences in the quality and quantity of student contributions and the eliciting and processing of 25 sets of ideas becomes important. The Thinking Book provided one way of actively involving all students.

The problems associated with highlighting individual differences were expected and it was valuable to have to begin to understand the problems of coping in the classroom as opposed to developing a theory of learning. In relation to understanding of students three issues emerged which were largely unanticipated before implementing the ideas in the classroom.

a) <u>The importance of peer group factors in shaping the learning environment</u>

Within the Year 7 group the majority of students formed temporary friendship alliances with different people. Many of these short term alliance groups resulted in significant changes in the behaviour patterns for each of the participants. Students were clearly adopting new roles and behaviours in the new friendship groups and the learning conditions varied greatly for a number of students. Learning theories generally

fail to account for the effects of peer group interactions to anything like the extent found in our experience.

The approach to learning being developed may have accentuated the effects of peer group interaction. There was encouragement given to group and class discussion and group activities of various types. At this age, students are establishing relationships with peers and many are 'experimenting' to gain acceptance in new groups. Studying learning in the classroom situation therefore highlighted an important aspect of the learning conditions which is less obvious in the more clinical situations of earlier research.

b) Developing skills in metacognition. The approach to learning included a concern to have students develop an awareness and hence gain greater control over their own learning. The activities proposed by Baird and White (1982) formed the basis for our attempts to get students to ask themselves questions about the progress through a learning task.

e.g. 'What are we supposed to be doing?'
'Why are we doing this?'
'What has this got to do with yesterday's lesson?'
'Have I changed any of my opinions or views?'
'How can I use this?'

Students quickly understood the purpose of reflecting in this way and began appreciating the value of this approach. However we could not claim that this form of reflection became part of any student's learning behaviour; it would require far more intensive attention than the four occasions we encouraged use of these questions. There are plans to engage students in reflecting on learning in several subject areas with Year 7 classes at another high school. It will be interesting to see if there are more permanent changes in learning behaviour when a number of teachers emphasize the approach.

c) Individual differences: the critical dilemma. The approach to learning depended on eliciting student ideas, interests, and experiences related to each new topic. In theory this is the raw material on which the science teaching will occur. Interests provide clues to motivation and existing ideas and experiences provide directions for the types of activities which can be presented to students. In practice the teachers were often left with a bewildering range of individual differences and the

problem of narrowing this range to manageable proportions. The credibility of the overall approach may suffer when a student's initial ideas seem to be ignored as other ideas become the focus for the lessons. The assumption is that all students will become involved if the topic is developed in interesting and relevant ways. However even with so much care given to determining the initial status of students we can report that the assumption rarely holds true.

In one respect students did not differ greatly. Science was perceived as a subject which had correct answers to the problems posed and although they accepted activities which made them think and perhaps change their ideas they found comfort in the 'right' answers. They sought the 'correct' answer while tolerating the learning process.

CONCLUSIONS

Our aim in taking the Year 7 class was to increase our understanding of the learning process. In simple terms we were trying to apply our ideas and White's analysis of the term 'understanding' further clarified our purpose. Each target of our understanding has been affected by our experience. Two examples can be used to show how this occurred.

Our understanding of the learning approach has been modified by our understanding of students at this level. The effects of peer group interactions have been underestimated as a factor in the learning environment. As a further example we can see that some ways in which schools are organized are not conducive to the implementation of the learning approaches being presented. Schools are organized so that groups of age cohorts can function effectively. The result is that school classrooms are a compromise where competing functions of schooling and the constraints that are operating are 'balanced'. The ideal conditions for our approach to learning could not be present and two visitors from the 'ivory tower' were grateful for the opportunity to better understand a secondary school and a group of its students.

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TRANSITIONS AND STUDENT TASK INVOLVEMENT

Jim Butler and Warren Beasley

INTRODUCTION

The focus of this study is the pattern of student task involvement before, during and after teacher initiated transition. This is a complex area of study with little published research (Arlin, 1979), but about which teachers share a body of practical wisdom. For example, if an activity setting is going badly, it is commonly believed by teachers that order can be restored if the students can be induced to enter a new setting. In other words transitions can reinstate the teacher as manager.

A transition is defined as any teacher initiated directive to students to cease one activity and commence another (Arlin, 1979; Evertson, 1982). In this study substantial segments of the lesson must be involved in the change-over for it to be classified as a transition.

There are three settings that constitute most science lessons: (a) Whole class activity (WCA) - where all students are in one large class group attending to a single signal source which is usually the teacher (Kounin and Doyle, 1975); (b) Small group activity (SGA) where the students are in small groups involved in experiments or discussions; and (c) Individual activity (IA) where each student works alone on an individual task.

In most science lessons these settings occur in predictable sequences. The first pattern - called the explanatory lesson - starts with WCA when the teacher explains new material, this is followed by the IA setting where the students practice the new learning, then finally back into WCA for a recapituation. The second pattern - called the practical lesson - starts with WCA where the teacher states the aims and procedures and recalls the content of the practical work, then the students move into

SGA to perform the experimental task; the final setting is WCA where the teacher collects the apparatus, collates the results and highlights the learnings to be abstracted from the practical activity. In summary then, there are two major lesson patterns; (a) Explanatory lesson: WCA - IA - WCA and (b) Practical lesson: WCA - SGA - WCA

The four distinct types of transitions implicit in these predominant lesson sequences were observed and constitute the transitions examined in this study.

A study that has made a direct contribution to the question of task involvement and transitions was that by Arlin (1979). The subjects involved were trainee primary teachers who taught sequences of lessons, so the transitions between lessons would be much the same as within lessons. Arlin compared the time off-task for the class of students during one minute of a transition with that during the third minute after a transition was completed. In other words, the third minute of the new activity setting. Thus Arlin can be interpreted as reporting on student off-task behaviour during a transition as compared to very soon after a transition. Arlin's conclusion was that the off-task behaviour during transition time was about twice that during regular classroom time. Arlin attempted to extend his study into high school classrooms but found both the framework and observational system inadequate for these higher grades. It is this extension of Arlin's work that is attempted here.

THEORETICAL FRAMEWORKS FOR TRANSITIONS

The four distinctive transitions considered in this study will be analysed from an ecological perspective (Doyle 1979).

The distinction introduced above between "explanatory" and "practical" lessons will assist in the analysis of transitions. In the former lesson, information usually in the form of verbal explanations flows from the teacher to the student. The focus of the student attention is on comprehending and assimilating the new material. On the other hand, the central piece of the practical lesson is an experimental activity, usually a coherent sequence of manipulative steps to be performed by a group of students. In this case the real focus of student attention is the practical tasks and not 'learning' as this might be viewed by the teacher or curricular theorists (Westbury, 1978). It is usually only in the final WCA setting of the practical lesson that the students are constrained to 'learn' or abstract' in the sense of the explanatory lesson.

Two theoretical frameworks are introduced by Arlin (1979). The first 'time flow' refers to pacing of the information flow. If the teacher makes an accurate reading of the appropriate steering criteria of learning, Arlin believes that 'time-flow' is optimal and the transition out of an information giving setting into a new setting will be smooth and accompanied by little student disruption. The opposite will be true if the teacher, for whatever reason, makes the transition too early or too late.

This framework has obvious relevance in an explanatory lesson, where the first transition is from a WCA setting into an IA setting, from teacher explanation into student individual practice or summary.

The second framework Arlin (1979) calls activity flow. The central idea is that classroom tasks, such as experiments, have a delineated sequence of behavioural acts that are provisioned and signalled by physical objects. If the experimental procedure has been properly designed and the task is able to be peformed by the students and all appropriate objects are present then the sequence of actions to be performed by the students flows continuously and smoothly to its completion. The activity is said to have momentum and a continuous and unlagging signal system, and is accompanied by high levels of student task involvement (Kounin and Doyle, 1975). Transitions that occur before the activity sequence has been completed are discontinuities and disruptive of student task involvement.

The two frameworks derived from Arlin's work can be termed psychological; but they are premised on the social order of the classroom. Clearly, the cooperation of the students in the setting is prior to any consideration of time flow or activity flow. This leads to a third perspective on transitions. In social settings, the individual encodes cohesiveness with the other members as well as interest in the situation itself by giving or withholding attention to the activity at hand (Goffman, 1963). From this viewpoint, the classroom teacher who is responsible for gaining the cooperation of students in educationally significant social settings, is ineluctably drawn to rely on the students' behavioural cues of involvement to guage the success of an activity (Jackson, 1968, p.120). If the teacher cannot gain the cooperation of the students in the setting then some intervention, usually in the form of a transition to a new activity pattern, will ensue. It is known that some classroom settings are more coercive of student task involvement than others (Kounin and Doyle, 1975; Evertson, 1982) and that it is therefore possible for teachers to regain the order of the classroom by a transition to a

new setting. In these circumstances it would be anticipated that the transition would break into the high level of pupil disruptiveness and reduce it.

The three frameworks presented so far are teachers' perspectives on transitions. But the students can have their own interpretations and responses to transitions, which are quite separate from the intentions of the teacher. The activities that make up the transition are usually quite different from the activities constituent of the learning settings. These transitional activities can be characterized as organizational and physical - they require the student to move, to retreive, to set up, to find, to form groups, etc. On the other hand the learning activities usually require concentration and effort, with low levels of physical activity. From the student perspective the transitional period, under most circumstances, may bring relief from cognitive strain and physical passivity. The tasks set for the student in the transition may be more palatable and a welcomed relief and thus ensure higher levels of task involvement, provided they ar efficiently conducted and purposeful. On the other hand, because the teacher is often involved in organizational matters during a transition, teacher surveillance may decrease, and the students respond to this by attempting those off-task behaviours that were not possible under the regime of the previous setting.

In summary, it appears from a consideration of the four frameworks that it is not possible to decide generally if transition will disrupt, enhance or leave unchanged the level of student task involvement. The students' response to a transitional phase in the lesson is determined by the resultant of many influences that come from the task, the teacher, the settings and the individuals themselves.

METHODOLOGY

The intention of the project was to observe naturalistically within the science classroom setting. The subjects for the study were the teachers and pupils in 24 junior science classroom in six metropolitan schools. There were three Grade 8 classes, twelve Grade 9 classes and nine Grade 10 classes, with a median class size of 27 (range 20-36). There were 16 men and 8 women teachers. It was planned that each class would be observed in four science lessons, each about a month apart. Ninety-one of the intended ninety-six lessons were recorded on videotape by two cameras, one directed at the teacher and the other at the students.

Six students were selected for observations from the videotape following a procedure that assured equal representation from all regions of the room. The behaviour of these students was coded by six trained coders whose observer agreement coefficients had a mean of .72 (Butler et al. 1980). Each of the six students was coded continuously throughout the whole of the observed lesson. The ninety-one lessons were divided into the three lesson settings of WCA, SGA and IA. The transitions chosen for this study were those which separated lesson settings which existed for a period of at least 5 minutes.

The crucial feature of the methodology that needs to be discussed is the coding of off-task behaviour. The student behaviours were coded as off-task if they were outside the implicit or explicit behavioural expectations of the teacher. These expectations changed significantly from one setting to another and in the transition periods between settings. The on-task and off-task sets of student behaviours were defined for each type of setting and for each type of transition. Some behaviours - like throwing objects - are always in the off-task set; but some others - like student talk - can transfer between the two sets depending on the setting, or type of transition.

The off-task sets in each of the three settings generally overlap but do have unique features. For example, animated 'student-student' talk is off task in WCA and IA, but not in SGA where it is essential to the setting. As concerns coding, the WCA and IA settings generally show up off-task behaviours more starkly than SGA where it is more difficult to decide.

The off-task sets of student behaviour in each of the four types of transitions are also distinctive in minor ways. The two transitions in the explanatory lesson are generally brief: WCA into IA had a mean time of 54 seconds while the reverse, IA into WCA took an average 35 seconds. These two transitions involve little reorganization or activity on the part of the students. In the practical lesson the first transition, WCA into SGA lasted on average for 130 seconds and the reverse for 160 seconds, which indicate the many things that often have to be achieved in these transitions. The two brief transitions in the explanatory type lessons would have similar off-task sets of student behaviours to the two settings they separate. However, the two transitions in the practical lessons have sets of off-task behaviours more like the SGA setting, and therefore have fuzzier boundaries than the fairly sharp ones in the explanatory lesson.

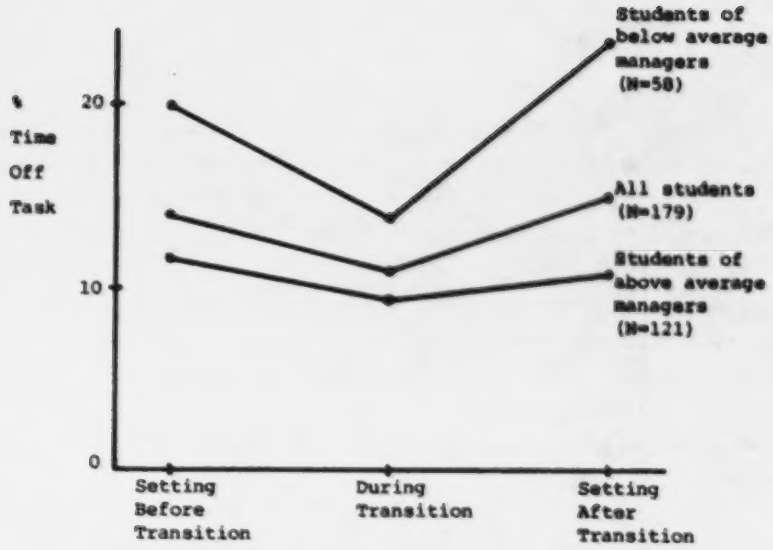

Figure 1. Effect of transitions on student task involvement.

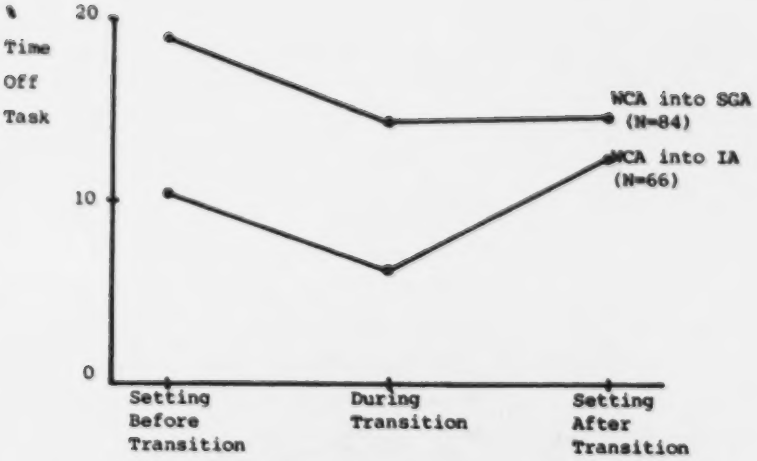

Figure 2. Students' off-task behaviour during specific transitions.

RESULTS

The thirty-two lessons (with 46 transitions) accepted in this study were taught by 15 teachers and contained the four types of transitions described previously. The data represent the mean off-task behaviour of all students which were observed in the settings before, during and after transitions.

The effect of transitions on student task involvement across all thirty-two lessons is presented in Figure 1. The results displayed represent the mean percentage off-task behaviour for all students and in separate graphs, the off-task behaviour in classes with above average and below average science classroom managers. The average off-task behaviour of the students of the 24 teachers across ninety-one lessons was thirteen percent.

For all students the obseved off-task behaviour during the transition period was significantly ($p<.05$) different from that observed before ($t=2.16$, $N=179$) or after ($t=2.06$, $N=179$) the transitional period.

For the above average managers, there was no significant difference across the three means. For the below average managers the mean during the transition was significantly different from the setting after ($t=2.2$, $N=58$).

The data can also be segmented into specific transitional types. The mean student off-task behaviours across the two types of transitions for which there were sufficient data are presented in Figure 2. In the case of the transition WCA into SGA, the mean of the student off-task behaviour before the transition is significantly ($p<.05$) different from that during the transition ($t=2.18$, $N=84$). For the other transition, WCA into IA, the mean off-task value during the transition is significantly ($p<.05$) different from the mean value for the IA setting after the transition ($t=2.23$, $N=66$).

DISCUSSION

The results consistently fail to show the increase in the level of off-task behaviour that Arlin (1979) reported in primary classes taught by trainee teachers. In the case of all students in four types of transitions the off-task behaviour rate was significantly lower than in the settings on either side of the transition. The two theoretical

frameworks of Arlin (1979) predict an unchanged or increased level of student off-task behaviour, so they do not appear to be the dominant processes in these secondary science classrooms. In the transitions used in this study none were judged to be precipitated by students being out of control and generally uncooperative, so that the third framework is probably unsuitable. This leaves the only explanation for the decrease in the level of student off-task behaviour, in the positive influence of the fourth framework. It seems to indicate that the students find relief in the transitional period and cooperate more fully in the expected behaviours. This explanation is reinforced by the results displayed in Figure 2. The brief, low activity transition from WCA into IA does not change the level of off-task behaviours, but the longer, highly active transitional period from WCA into SGA significantly reduces the off-task level. The positive aspect of the fourth theoretical framework appears to be the predominant influence.

The results produced by the above average and below average managers are consistent with the fourth theoretical framework. The better managers of classrooms are the better managers of transitions which cause no significant change in the off-task behaviour, and fit into the flow of the classroom. In the case of the below average manager the transition does cause a signficant decrease in the off-task behaviour, and can probably be interpreted as the students in these classroom experiencing much greater relief from the fairly disorganized settings on either side.

In conclusion, it appears that in secondary science classrooms transitions are periods of reduced levels of off-task student behaviour, which is the opposite of what Arlin (1979) found in primary classrooms. This discrepancy obviously needs further study. Similarly, a more thorough test of the two Arlin (1979) frameworks and the two introduced in this paper needs to be undertaken.

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A SCHOOL-BASED, MULTI-FACULTY ACTION RESEARCH PROJECT TO ENCOURAGE METACOGNITIVE BEHAVIOUR

Ian Mitchell and John Baird

This paper reports the first term's progress of an action research project at a Melbourn High School where the first author teaches part-time. The project applies more widely earlier work of the second author. In this work, Baird identified a range of poor learning strategies which resulted in ineffective learning (Baird & White, 1982). These strategies were symptoms of a lack of informed, active involvement in learning: students failed to analyse and integrate information effectively, were inadequately aware of the nature and extent of their learning, and were unable to assume control of learning progress and outcome.

Each of these symptoms concerns metacognition - the knowledge, monitoring and control of one's own learning. Baird postulated that these learning strategies were remediable through training for enhanced metacognition.

At the end of 1984, the PEEL (Project for Enhancing Effective Learning) group was set up by the authors. The intention was to extend Baird's work to a two-year study involving a large number of teachers, several different subjects and several year levels. Currently, ten teachers from six faculties (English, History, Geography, Integrated Studies, Commerce, Science) and five classes (1 Year 7, 2 Year 9, 2 Year 10) are participating in the project. The multi-faculty nature of the project is seen as important. PEEL classes spend an average of about one-third of their weekly classes with teachers in the group. It is hoped that this situation will foster student change by alleviating the problem of limited generalisability associated with subject-specific training.

EFFECTING CHANGE

Perspectives which guided implementation

Enhancing metacognitive behaviour in students requires that staff also change.

Change for staff is seen as different classroom procedures, teaching styles and, probably, assessment procedures. Behavioural change for both staff and students will probably require alteration of attitudes to, and perceptions of, learning and teaching (Baird, 1984).

Change is seen as a slow, personal process which frequently occurs as a consequence of trying new procedures. The matter of implementation of procedures to be used took account of two models of change: Hall's (1978) Concerns Based Adoption Model and Hewson's (1981) notion regarding the requirements for acceptance of a concept. Hall states that teachers exhibit different concerns at different stages of use of an innovation. These concerns must be addressed and surmounted in order that the innovation be adopted. Hewson proposes that a concept will not be accepted and used unless it is intelligible, plausible and fruitful to the user. In this project, Hewson's notion has been extended to the acceptance of an innovation. It was felt that the most appropriate method for fostering changes consistent with these perspectives was by participant action research (Baird, 1984): teachers control the procedures attempted and evaluate teaching and learning behaviours and outcomes; students evaluate procedures and monitor changes in learning behaviours and outcomes. In contrast to the well developed innovations studies by Hall, participants in this project are researching both the nature of the innovations and its implementation. There are no right answers. All of the above means that effecting change requires participants to engage in personal development which takes considerable energy and time. They require adequate support.

Procedures for fostering staff change

The group meets weekly to discuss progress, share ideas and receive input on theory and procedures. The authors and other external consultants regularly observe lessons, talk to staff and participate in the group meetings. The staff also meet informally as form groups and faculty groups.

Initially, a small set of procedures together with an overview of the project were presented to the staff. The perspectives on change outlined above led to the decision to introduce staff to major ideas and models gradually as they gained classroom experience with these procedures. Such ideas included more detail of Baird's work, Barnes' views on transmissive versus interpretive teaching (Barnes, 1976) and the models of Hewson and Hall.

Procedure for fostering student change

At the beginning of the project, staff gave students information about passive

learning and poor learning strategies, and then introduced them to the rationale and purpose of the project. They were given an exercise book (called a diary) to use for the tasks described below. The diary was kept separate from other subject notebooks, in order to emphasise that what the student wrote was not for assessment. Participation in the project and use of the diary were voluntary.

Initially, the last five minutes of each lesson were set aside for students to write down what they thought were, the topic of the lesson, the main task of the lesson, why they had completed the task, and one thing that puzzled them during the lesson. Subsequently they were asked to complete other tasks, which included, determining the connection between the immediate lesson and the previous one, rating their learning behaviour and their level of understanding according to criteria supplied, and asking questions which required analysis and re-working of content.

OUTCOMES

Various results are emerging from the project even after only one term.

Effects on the Students

Initially, the students' behaviour provided clear support for the conclusions that students are usually passive learners (e.g. Osborne & Freyberg, 1985). Active learning is something they have been unused to and are reluctant to attempt. However, most teachers in the group now agree that students have improved at framing and asking questions. A small number of students at each year level have expressed enthusiasm for the project procedures, and have already begun incorporating them into their classroom procedures. Particularly, there has been a change in the behaviour of some passive students. As time progresses, these students have begun contributing to class activities, at first hesitantly and then with growing confidence. They now show more evidence of actively self-evaluating lesson nature and progress. There have also been improvements with a few problem students. These students frequently rebel against what they see as the repressive nature of normal classroom procedures. They have appreciated the increased opportunities to question, criticize and express their views.

Generally, however, the initial procedures did not work as well as intended. Student change has been very slow and uneven. Although students acknowledged that PEEL involved a lot more thinking than normal, they had inadequate perceptions of the

nature and importance of the procedures and, in particular, of the nexus between these procedures and improved performance. The increased thinking has, in many cases, not been seen as fruitful by the students. Typical comments have been, "we are doing too much thinking and not enough work", "we are not getting on with the work", "all this thinking means we are getting behind". By work, the students mean writing down notes. In part, inadequate perception of the efficacy of procedures is because reinforcement given to them regarding the 'pay-off' of changed behaviour has been inadequate and too long-term. In the crucial first weeks, the staff were too inexperienced and unfamiliar with the innovation to generate reinforcing situations.

For these reasons, students were not ready for the diary in the way it was originally presented and used. It separated "PEEL work" from school work, and thereby created an unintended barrier: "PEEL work only occurs in the diary". Many students said that, even though they were thinking better, it couldn't be due to the PEEL project because it was not due to what they wrote in the diary.

Across all year levels, peer group pressure has significantly influenced acceptance of a procedure, with students tending to attempt project tasks in groups, not as individuals. The initial procedures described above were particularly vulnerable to negative peer group pressure. These procedures required students to think and write in silence. In this situation, off-task or negative comments or behaviours by some students proved disruptive.

Effects on the staff

Usually a pay-off for teachers pursuing a new classroom strategy is positive student feedback. All staff have had some positive experiences, but because many students are still unconvinced about the value of the project the pay-off has been limited. Lack of positive feedback was accentuated initially by an initial decision not to collect the student diaries (in order to distinguish them from assessment tasks). It has since been discovered that some of the most favourable student responses appear as written diary entries and evaluations.

Probably the biggest personal cost for staff so far has been the difficulty of reacting productively when procedures have not worked as intended. Teachers usually do not have the luxury of revising and then trying again with a new class. They must bear the consequences of outcomes with their classes, where necessary re-establishing control, interest and motivation. This requires a high level of commitment to change by the teacher and represents another significant barrier to this kind of research.

Even with the negative effects mentioned above, at the end of term one all staff stated they were still fully committed to the project, with a majority stating they felt more positive about it than they did at the start of the term.

All staff assert that they have aquired important new perspectives and deeper understandings about various aspects of teaching and learning, and see this as a major personal benefit of the project. From early in the term, teachers began to realize that in order to generate some of the desired student changes they had to change. These new perspectives have led to staff becoming more interpretive.

The other major change is the extent to which staff have been willing and able to assume independent control of the research. Initially, nearly all were uncomfortable in the role of researcher and wanted to be told what to do. Gradually they have developed personal understandings of both metacognition and action research so that now nearly all are developing and implementing new procedures or reworking initial ones.

DISCUSSION

Training for enhanced metacognition through action research can produce substantial change in teachers and students. The changes occur slowly, with difficulty and at widely varying rates, but those who change are usually very positive about the nature of the change.

When the outcomes of Term 1 are considered in terms of Hewson's model reasons for the slow and uneven student change emerge. The types of classroom activities were very different and did not constitute plausible alternatives for many students. School is meant to involve a lot of note taking and rote learning. Certainly the strategies as implemented were not fruitful for most students. There was no apparent benefit, and improved thinking was seen as irrelevant.

For teachers difficult classroom experiences yielded positive effects as a consequence of on-going support. Group meetings have been generally positive and crucial to morale. The opportunities for regular discussion with the authors and others have also been vital in maintaining momentum and in placing experiences within a wider educational context and in linking them to theoretical perspectives.

Staff who choose to participate in PEEL have had many of their self concerns met by the initial in-service. They still have some self concerns, related to time, effort and ability, but these have declined during the term. Their task concerns have been a major hurdle, and these have required changes to teachers and the initial procedures. The action research structure of PEEL has also forced staff to be concerned with impact issues. The processes have stimulated staff to become independent researchers more rapidly than would have been the case had they been using trialled and established strategies.

On-going support has been essential for the continuation of the project and for substantial teacher change with respect to their understanding of metacognition, their attitude to interpretive teaching and their independence as researchers.

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COGNITIVE VARIABLES IN PROBLEM SOLVING IN CHEMISTRY

Kam-Wah Lee

INTRODUCTION

This paper presents some details of an investigation to examine problem solving. The investigation addressed the following questions: What cognitive variables are significant in problem solving performance? What are the relationships between these variables in problem solving performance? In what ways do these variables relate to the problem solving performance of different types of problems?

The topic of electrochemistry at H.S.C. level in Victoria was selected as the chemical context for the investigation.

VARIABLES AND INSTRUMENTS

There are six independent variables (or predictor variables); concept relatedness (CR), idea association (IA), specific knowledge (SK), non-specific but relevant knowledge (NSRK), problem translating skill (PTS) and prior problem solving experience (PPSE) and one dependent variable (or performance variable) (PSP). The study also included an investigation of the role of predictor variables in three different types of problems. Some of the predictor variables have specific measures for each of the problem types. There are also four measures of the performance variable: problem solving performance for Problem-1 (PSP1); for Problem-2 (PSP2); for Problem-3 (PSP3); and, overall, for Problem 1, 2 and 3 (PSP). The score of PSP is the sum of PSP1, PSP2 and PSP3.

Six instruments for measuring these variables were developed.

SAMPLE

The students and teachers in six secondary schools in Victoria - four government high schools and two independent schools (2, males only; 1, female only, and 3, co-ed) took part in the study. 214 Year 12 chemistry students in 11 classes (15-24 students) were involved.

The six instruments were administered in 1984, before and after the topic of electrochemistry had been taught in Year 12 classes. The tests were administered by the researcher in two school periods within two weeks. The sequence of administration was: Concept Relatedness Test, Association Test and Verbal Knowledge/Intellectual Skill Test in the first session; Problem Translating Test, Problem Solving Test for Students and Prior Problem Solving Experience Probe in the second one.

Four sets of data for the predictor and performance variables on (1) overall problem, (2) Problem-1, (3) Problem-2 and (4) Problem-3 were analyzed.

RESULTS

Correlation analyses

Correlations were calculated for the predictor and performance variables for Problem-1, Problem-2 and Problem-3 and the overall problem. In order to gain a better insight into the influence of the predictor variables in the problem solving, the predictor variables were also grouped into three "block predictor variables". Problem translating skill and prior problem solving experience which affect the response to the problem statement were combined and called "problem recognition skill". Concept relatedness and idea association which deal with the types of association involving the information store, were grouped as "linkage". The specific, and non-specific but relevant knowledge, relating to the capacity of the memory store, were combined as "prior knowledge". The correlations between these block variables and the performance for the three and overall problems were also calculated.

There are five important findings from these analyses:

(1) Problem solving performance correlated significantly with the block predictor variables : problem recognition skill, linkage and prior knowledge.

(2) Problem recognition skill, linkage and prior knowledge are moderately correlated

with each other. Problem recognition skill is more related to linkage than to prior knowledge.

(3) Within the block predictor variable, problem recognition skill, problem translating skill correlates with overall problem solving almost the same as prior problem solving experience; for the linkage block variable, idea association carries more weight than concept relatedness; and for the prior knowledge block variable the non-specific but relevant knowledge in general contributes slightly more than specific knowledge in solving each of these three problems.

(4) Among the predictor variables, concept relatedness least correlates with other predictor variables. The non-specific but relevant knowledge is also lowly correlated with the prior problem solving experience. The other single predictor variables are moderately and significantly correlated with each other.

(5) The performance variables of the three problems correlate with each other as would be expected for problems in the same field of electrochemistry and the correlations follow the degree of familiarity (or difficulty).

Multiple regression analyses

Regression Model

Multiple regression analyses were conducted for the overall problem and for each of the three problems separately. The interaction of the variables was first explored in the process of developing the best regression model. The R^2 of the regression model containing the six predictor variables (Model 1) was compared with the R^2 of a regression model containing the six predictor variables and the interactions of these variables (Model 2) for the four measures of problem solving performance. The results of these regression analyses (Table 1) when combined indicate that the effect of the interactions are insignificant in all four problem solving situations.

Three other models of regression were then considered in the following way. Each time a pair of the predictor variables corresponding to one of the block variables was removed from Model 1. Model 3 contains the two block variables of linkage (L) and prior knowledge (PK), Model 4 contains those of linage (L) and problem recognition skill (PRS). Model 5 contains the component variables of prior knowledge (PK) and problem recognition skill (PRS). The R^2 of Model 3, 4 and 5 are also shown in Table 1.

TABLE 1

R^2 of the Five Models

MODEL	VARIABLES	OVERALL	P-1	P-2	P-3
1	Six predictor variables	0.399	0.178	0.366	0.255
2	Six predictor variables plus interactions	0.418	0.217	0.391	0.315
3	Component variables of L and PK	0.292	0.143	0.292	0.151
4	Component variables of L and PRS	0.370	0.154	0.315	0.243
5	Component variables of PK and PRS	0.330	0.126	0.297	0.231

About 40% of the variance of the overall problem solving performance is accounted for by the six predictor variables (Table 1). Problem recognition skill is the most influential of the block predictors, linkage the next and the prior knowledge the least important. Out of the 40% of the variance, the three block predictor variables account uniquely for ?1%.

The best regression model for problem solving performance is Model 1 that contains the six predictor variables.

For Problem-1, about 18% of the variance of problem solving performance is accounted for by the six predictor variables (Table 1) and about 11% by the block predictor variables. Linkage appears to be slightly more important than problem recognition skill. However, prior knowledge is not statistically supported as a significant predictor for problem solving performance.

For Problem-2, about 37% of the variance of problem solving peformance is accounted for by the six predictor variables and 19% by the block predictors. Linkage, prior knowledge and partially familiar problems. Linkage and problem recognition skill turn up as better predictors than prior knowledge.

Importance of component variables in the block predictor variables

Each of the two components of block predictor variables has different degrees of influence in problem solving performance. Several more regression analyses were conducted on the four measures of problem solving performance to identify which of the component variables is more important. The unique R^2 for concept relatedness and idea association in the variance of overall problem solving performance when linkage alone was regressed were -.04 and 0.20. The unique R^2 of specific and non-specific but relevant knowledge on the overall problem when prior knowledge alone was regressed were 0.03 and 0.07. The unique R^2 of problem translating skill and prior problem solving experience on the overall problem when problem recognition skill alone was regressed were 0.10 and 0.09.

These results indicate that (1) idea associated is much more important than concept relatedness in the role of linkage, (2) non-specific but relevant knowledge is slightly more important than the specific knowledge in the role of prior knowledge, and (3) problem translating skill is almost as influential as the prior problem solving experience in the role of problem recognition skill in problem solving performance. These findings are consistent with the results obtained in the correlation analyses.

In summary, problem recognition skill, followed by the linkage, and then prior knowledge do appear to be predictors of this sort of problem solving performance in chemistry. Furthermore, the single variable, problem translating skill, contributes almost the same as prior problem solving experience. Idea association contributes significantly and substantially more than concept relatedness, and non-specific but relevant knowledge contributes slightly more than specific knowledge. The first line of Table 2 summarizes the results of these regression analyses for overall problem solving.

TABLE 2

Summary of Regression Analyses Results

Type of Problem	Best predictors
1. Overall (ranged from familiar to unfamiliar)	Problem Recognition Skill (Problem Translating Skill ≅ Prior Problem Solving Experience) > Linkage (Idea Association > Concept Relatedness) > Prior Knowledge (Relevent but Non-specific Knowledge > (slightly) Specific Knowledge)
2. Problem-1 (familiar)	Linkage > Problem Recognition Skill
3. Problem-2 (partially familiar)	Problem Recognition Skill ≅ Linkage > Prior Knowledge
4. Problem-3 (unfamiliar)	Problem Recognition Skill

SOLVING PROBLEMS: A DESCRIPTION

For persons to solve a problem, translation of the problem's statements into statements that are meaningful to them must be done before they begin the other processes of solution. The adequacy of this translation will depend on whether the meaning imposed by the reader on the problem's statements maintains their original intentions. An adequate translation is one in which these intentions are maintained. An inadequate translation is one where these intentions are not maintained and ought to preclude a solution except that there may be compensating mistakes that still lead to a "correct answer" from quite incorrect reasoning. The process of translation will involve identification and association with components of the problem's statements including identifying what is the question to answer. Prior experience of similar problem statements and of their successful solution is also a factor that is likely to lead to adequate translation. Once the problem statements have been adequately translated,

the making of relevant linkages to rules or facts become very important for the successful solving. In addition there are linkages to be made between these rules and facts and the information in the problem so that a solution sequence is possible. Some persons can be very knowledgeable (in a fragmented sense) in the knowledge area of the problems and yet be unable to solve them. They seem to be unable to link or associate these pieces of knowledge into a sequence that can lead to a solution. A variable which relates to these 'linkage' processes would thus be a more significant predictor than 'prior knowledge'.

Some deviations from this description of the way the best predictors operate as a hierarchy emerge when the different types of problems are considered.

For Problem-1, many students were familiar with the problem, so that their translations of the problem statements were adequate. The measures of translation were highest for this problem. In this case, the relevant linking of their translation to rules, algorithms or ideas became the essential determinant for successful problem solving. Without linkages between the rules and the components of their translation of the problems statements, there is not likely to be criteria which will enable problem solvers to identify rules or facts which will be inappropriate and ought to be rejected. In such a problem type, the findings from the data are that linkage is the most important predictor which is consistent with this account.

For Problem 2, many students were not very familiar with the problem. Hence they were unable to do the translation adequately. It is not surprising that the translating turns out to be the equally important predictor compared to linkage for the solving of this problem. Of course, prior knowledge is always significant since you would not be able to call upon the appropriate rules or facts if you do not know them. Nevertheless its significance in reaching a solution is less than the other two variables.

For Problem-3, an unfamiliar problem, the result indicates that problem recognition skill, (a measure of the translation process) was dominant as the predictor variable in the problem solving performance. Most students were unable to translate this problem's statements adequately so the correctness of their knowledge and the extent to which they could make linkages of it could not contribute to a solution.

CONCLUSION

A problem solver who is successful in securing a solution will need to achieve in relation to the three tasks to which these variables relate : first, the adequate translation of the problem's statements; second, the correct recalling of prior knowledge such as rules and facts and, third, making the relevant linkage between the problem's statements and rules and facts so that a solution sequence emerges. If he or she is familiar with the problem then the tasks of linkage and translation will play the important role in predicting the problem solving performance. For a problem with which he or she is only partially familiar, the three tasks stated will all contribute significantly to the problem solving performance. For an unfamiliar problem, the task of translation will be the best predictor of the problem solver's performance.

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HEALTH ATTITUDES AND HEALTH AWARENESS IN HIGH SCHOOL STUDENTS

Max Maddock

INTRODUCTION

In 1982 a pilot study of attitudes to community and personal health and awareness of health issues was carried out in high schools in the Hunter Valley of N.S.W. (Maddock, 1983). The study was aimed at evaluating specific objectives in the N.S.W. junior science syllabus (Secondary Schools Board, 1980). It was found that there was a strong, significant shift in attitude in a negative direction with increasing grade level (7-11), while at the same time a significant increase occurred in awareness of health issues. Zero level relationship was found between attitude and awareness, and between attitude and scores on classroom science tests.

Further studies with primary school children and nurses in 1983 (Maddock, Moore and Warren, 1984) showed that primary school children held more positive attitudes than high school children, and that although nurses were considerably more aware of health issues than the students, the relationship between their awareness and attitudes was very weak. The attitude and awareness link in the nurses seemed to be related to personal background factors.

THE PRESENT STUDY

During 1983, a further follow-up study was carried out in 10 high schools in the Hunter Valley of N.S.W., 3 high schools in Melbourne and in 3 high schools and 3 matriculation colleges in Tasmania. Students responded to a common personal factor identification questionnaire and two of the Community and Personal Health Attitude Scale (CPH), the Health Awareness Scale (HA) and the Health Behaviour Scale (HB),

paired randomly throughout the sample. The sampe sizes obtained were 947 for CPH, 895 for HA and 1394 for HB. The subjects were guaranteed complete anonymity.

The CPH and HA scales were the same ones used in the previous studies except that the number of items was reduced to 22 and 26 respectively by removing the poorest items identified in the pilot study (Maddock, 1983).

The Health Behaviour (HB) questionnaire is a questionnaire of 172 independent items not designed for summative scoring. The questions ask for information on specific aspects of exercise, diet, drug usage, sources of health information and behaviour models and family health history.

This paper reports the results of cross-grade and correlation analyses for CPH and HA and preliminary results carried out to date on HB to extract claimed drug usage.

Attitude (CPH)

A grade by state analysis of variance over grades 7-10 for CPH showed significant differences on both the grade and the state factors. The attitude showed the same trend as in the pilot study with mean shift in a negative direction from grade 7 to grade 10, the magnitude of negative shift being of the same order as in the earlier study. The grade 10 mean was 0.5 standard deviations lower than the grade 7 mean, with a F value of 4.58 significant at 0.004.

The F for the state factor of 5.79 was also significant ($p < 0.003$) with the Tasmanian mean being 0.2 standard deviations higher than the N.S.W. mean. There was no significent grade x state interaction.

Awareness (HA)

In the case of the awareness scale, the grade effect was strongly significant, the grade 10 mean being almost 1 standard deviation higher than the grade 7 mean (F 31.39, p 0.0000). This result is similar to that obtained in the Hunter Valley sample used in the pilot study in 1982. There was no significant state effect but Grade x State interaction was significant (p 0.03), with the Tasmanian Grade 10 mean 0.3 standard deviations less than the grade 10 mean, against the trend in the Melbourne and Hunter Valley.

TABLE 1

GRADE X STATE ANALYSIS OF VARIANCE

Scale	Source	Sum Sq.	DF	Mean Sq.	F	Probability
	Mean	1112797.0	1	1112797.0		
	Grade	544.8	3	181.6	4.58	0.004*
CPH	State	459.6	2	229.8	5.79	0.003*
	GS	298.3	6	49.7	1.25	0.277
	Error		822	32620.9		
	Mean	75672.3	1	75672.3		
	Grade	1762.2	3	587.4	31.39	0.000*
HA	State	27.9	2	13.9	0.75	0.475
	GS	261.0	6	43.5	2.3	0.031*
	Error	14426.9	771	18.7		

* Statistically significant

Attitude- Awareness Relationship

The correlation of 0.23 for the total sample (including grades 11 and 12) was positive and statistically significant ($p < 0.03$), of similar order to that found in the nurse sample (Maddock, Moore and Warren, 1984), but, as in the case of the nurses, represents only a weak relationship (5 percent of common variance). This indicates that attitude scores are of little value in predicting awareness and vice versa.

Attitude and Awareness Grades 11-12

In Tasmania, grades 11-12 pupils and in the Hunter Valley grade 11 pupils were also tested, but not in Melbourne. These results have not been included in the ANOVA

comparison. However, it is interesting to report that the grade 11 (Hunter Valley and Tasmania combined) mean was 0.3 standard deviations lower than the grade 7 mean, but the small (23 pupils) year 12 group from Tasmania had the most positive attitude for all grades (56.7, 0.3 standard deviations higher than grade 7).

In the case of awareness, the Tasmanian grade 12 mean (19.4) and the Hunter Valley - Tasmania combined grade 11 mean (17.9) were both higher than the grade 10 mean (15.8), the grade 12 - grade 10 difference being 0.8 standard deviations, and the grade 12 - grade 7 difference being 1.7 standard deviations, of similar order of magnitude to the grade 11 - grade 7 difference in the original pilot study.

Drug Usage

Work is still proceeding on the results from the Health Behaviour (HB) questionnaire, but the analyses on self-reported usage of drugs has been completed (See Table 2).

Significant percentage of pupils in grades 7-12 of the sample, ranging from 10 percent for heroin through 23 percent for marijuana to 55 percent for spirits, 66 percent for beer and 75 percent for wine, claim to have had some experience with using the recognized drugs of addiction. The percentages listed in the "occasionally or more" category, can be regarded as users beyong the experimentation stage.

It is always difficult to assess the accuracy of self reported behaviour responses, but the subjects had been guaranteed anonymity and the overall pattern of variation across the various behaviour items is consistent with reliable responses. Even if significant error were present, the extent of drug usage claimed is disturbing.

DISCUSSION

Increasing public concern is being expressed about drug abuse as one of the countries major health problems. Increasing attention has been turning towards eduction programmes as a means of influencing attitudes to health, and at the recent "Drug Summit" organized by the Federal Government, one of the major strategies mentioned was the spending of $ 60,000 for eduction. Much of the literature on health education programmes refers to the links between knowledge, attitudes and behaviour and the part that the programmes should play in developing such links.

TABLE 2

SELF-REPORTED DRUG USAGE

	Never	Once/Twice Life	Used to but Given Up	Occasionally or More
Tobacco	52	12	6	28
Marijuana	77	5	1	15
Glue Sniffing	83	7	2	6
Pain Killers	52	15	1	31
Pep Pills	89	3	0	6
Heroin	90	1	1	6
Beer	33	17	1	47
Wine	25	21	2	51
Spirits	45	17	1	35

Discrepancies from 100 percent total are due to rounding error accepting the option to refuse to answer the question

For example, the Queensland Health Education Curriculum Guide Grades 1-7 sets out main ideas aimed at promoting knowledge, attitudes, values and behaviour essential to individual, family and community health. The Western Australian Interim Report of the Health Education Advisory Committee states that a large number of health problems are a consequence of patterns of behaviour and attitudes developed while young and that these "patterns of behaviour, beliefs and attitudes can be influenced by a healthy school environment" (Health Education Advisory Committee, 1981).

The results of this study reinforce findings of previous studies, (e.g., Maddock 1983, Moore and Warren, 1984) that although awareness increases markedly with increased schooling, schools have not been very effective in achieving their stated attitudinal objectives. A significant negative shift in attitude was found between grade

7 and grade 10 for a sample which included Hunter Valley, Melbourne and Tasmanian schools. The sample is not claimed as being representative of any state, or Australian "typical" population, but it is sufficiently wide, and the results sufficiently consistent within it, to raise concern about the underlying assumptions of educationsl programmes.

As in the pilot study (Maddock, 1983) and the study with nurses (Maddock, Moore and Warren, 1984), there is no strongly demonstrated relationship between attitude to health matters and awareness (knowledge) of health issues to the extent that confidence could be placed in raising awareness as a means of affecting attitudes and thus, hopefully behaviour.

Attention has recently been focussed on the interaction of a range of factors on awareness, attitude and behaviour in health matters. Eight years ago a review of Iverson and Portnoy (1977) found that health education programmes have demonstrated ability to increase knowlege levels and foster positive health attitudes but that these were not important factors in adoption of satisfactory health behaviour.

School or wider public education programmes need to extend beyond "information providing" as one of their cornerstones. More effective programmes have to depend on a balanced analysis of internal (attitudinal) and external (social normative) factors, both dimensions being so entwined that any attempt to dichotomize adds nothing to their relative contributions (Green, 1970).

It is hoped that the analyses still to be completed on the CPH, HA and HB questionnaires will help to throw some light on some of these socio-cultural issues.

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LIVING AND LEARNING IN A HECTIC WORLD:

STUDENTS' PERCEPTIONS OF STRESS

Jan Garrard and Margaret Brumby

INTRODUCTION

This paper describes an investigation into students' understandings of stress, its effects, and their coping skills. It is a part of a wider investigation of students' beliefs about health. Garrard and Brumby (1984) found that the concept of mental health featured prominently in students' responses to two very general questions seeking their beliefs about factors that influence their health and how long they expect to live. Many of the students' which were categorised under 'mental health' were in fact references to stress.

While many psychologists have challenged the usefulness of the concept of stress because of difficulties in theoretically and operationally defining the concept, the fact remains that, on an intuitive level, stress is a fact of everyday life - the so-called "twentieth-century plague" (Ciaranello, 1983). Mason (1975) argues that the persistent, widespread use of the word stress despite almost chaotic disagreement over its definition is an indication of the validity and usefulness of this term.

Stress research over the past 50 years has resulted in marked changes in the concept of stress. Mason (1975) discusses the evolution of the concept of stress from stress defined solely in terms of stimulus parameters; to stress defined solely in terms of response parameters; to stress defined in terms of stimulus - response interactions; and finally to stress as a general rubric which encompasses the whole spectrum of interacting factors - stimulus, response, and the intervening processes such as appraisal of threat and coping styles.

The model of stress which will be used in this study is based on the empirical

findings and theoretical formulations of Lazarus and his colleagues (Lazarus & Folkman, 1984). The proposed model of stress is shown in Figure 1.

Stimuli are part of the physical and social environment and are potential stressors. Perception and cognitive appraisal of stimuli lead to assessment of the stumuli as benign, neutral or stressful. It is only when a situation is appraised as stressful that a particular stimulus becomes an actual stressor. Cognitive appraisal of a stimulus as harmful, threatening or challenging (i.e. as a stressor) leads to affective reactions such as anxiety or apprehension which in turn activate the physiological defense mechanisms that result in somatic tension.

Cognitive appraisal influences the nature and intensity of the affective and somatic responses, and appraisal and responses together influence both the choice and the effectiveness of coping strategies.

Over the past few decades findings from stress research have become more generally known. However, most publications and courses have been aimed at the well-educated adult population with the result that many adults and most children and adolescents have limited access to this information.

For most people at present, learning how to cope with stress is still largely an individual enterprise. People still learn (or fail to learn) largely through their own experiences with life.

Arguably, learning about stress can be achieved more equitably and efficiently through the education system. Within the school curriculum, teaching about stress is now beginning to be included in subjects such as social and human biology, home economics, human development and society, and health education.

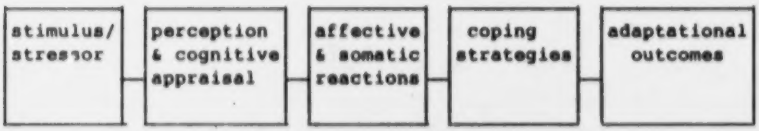

FIGURE 1. A MODEL OF STRESS

Extensive recent research in science education has shown that new learning is most successfully achieved when it is based on a sound foundation of what the student already knows (Novak, 1977). The research reported in this paper explores in some depth students' knowledge and experiences of the wider aspects of stress - what the concept of stress means to them, how they feel when stressed, and how they cope with stressful situations. The aim of this study is to provide data on which education about stress can be based.

There have been few systematic attempts to assess children's and adolescents' experiences of stress. In most cases research focused on identifying potential stressors in students' lives with little attention to the wider aspects of stressful encounters.

For example, Collins and Harper (1974) found that the academic side of school life such as examinations, and parental pressure to succeed were major concerns for adolescents. Students may also perceive their school teachers to be causative agents in that they create the conditions that can make school pleasant or unpleasant (Applegate, 1981).

STUDENT POPULATION

Thirty-nine secondary students in Year 10 at a co-educational metropolitan high school in Melbourne and 51 tertiary students from Monash University took part in the study. The secondary students consisted of two complete classes. The tertiary students were the total population of science graduates enrolled in the Diploma of Education course at Monash University and taking at least one science method.

DATA COLLECTION

The results reported in this paper are part of a wider study of students' understanding of health. One of the instruments used was a semi-structured clinical interview. Interviews lasted approximately 45 minutes and were audio-tape-recorded and independently transcribed verbatium. Identical wording was used to introduce each question to the student and care was taken not to 'cue' the student in any way. The questions which are analysed in this report are as follows.

Students were shown a Scrabble board with letters spelling the word STRESS in the centre of the board. Students were asked:

Question 1

Some people have described modern life as stressful. If you had a game of Scrabble with a friend, and you started with this word and your friend said 'What does that word mean to you?', how would you go about explaining it?

Question 2

Have you had any experiences in your own life that you would call stressful?

DATA ANALYSIS

Questions one and two were analysed for their conceptual content. For each question the concepts used by the students were listed and then scrutinized to form common areas or categories. (i.e. categories of analysis where not predetermined).

The number of students who mentioned a concept within each category was recorded and the percentages of students who gave responses in each category was calculated. Thus, the percentages represent the number of students who responded in that category compared with the total number of students. Because many students produced several different ideas in response to each question percentages are not additive.

RESULTS AND DISCUSSION

Q1. Students' explanations of the meaning of stress

Like the 'experts', students have difficulty defining the word stress. Very few students actually attempted a formal definition of stress. Most students' explanations of stress either made use of a synonym such as "pressure" or "tension" or described stressors in their lives or the effects that stress has on them.

The most commonly used synonym for stress was "pressure". This word was used by 50% of secondary students and 30% of tertiary students. Other words used to describe stress were: tension, worry, nervousness, anxiety, problems, strain, and

frustration. In all, 80% of both secondary and tertiary students used words such as these synonyms to describe stress.

In addition to statements that stress is pressure, tension, worry, etc., many students went on to describe stress in terms of where the pressure, tension, worry, etc. comes from (i.e. stressors), how it affects them (i.e. reactions to stress), and what they can or cannot do about it (i.e. coping).

Sixty-five per cent of secondary students and 70% of tertiary students mentioned a particular stressor when describing their understanding of the word stress.

A fewer number of students mentioned their reactions to stressors. These responses included both physical (e.g. headache) and emotional (e.g. feeling irritable) reactions.

Although the most frequently mentioned effects of stress were negative, 15% of tertiary students mentioned positive stress responses, such as:

"It's funny because a lot of positive things have come out of stress for me."
(tertiary student)

"A certain amount of stress is good in anybody's life, it keeps them on their toes."
(tertiary student)

This perspective of stress having positive effects was absent in the Secondary students.

In all, 30% of secondary students and 35% of tertiary students mentioned one or more stress reactions or outcomes when describing their understanding of the word stress. Although only fifteen percent of secondary students and ten percent of tertiary students mentioned coping when describing their understanding of stress it should be noted that many students showed an intuitive understanding of the role of coping within the stress paradigm. These were the students who made reference to the number of stressors as well as naming specific stressors. Statements such as:

"A lot of problems." (secondary student)

"Pressure builds up." (tertiary student)

were made by 50% of secondary students and 30% of tertiary students.

The richness of the data in terms of students' personal experiences and the almost complete absence of 'theoretical' definitions of stress indicate that students' understanding of stress is highly experiential rather than formal. In terms of the stres model discussed earlier students showed greatest awareness of stressors in their lives. Fewer students mentioned the physical or emotional effects of stressors, and even fewer students again mentioned the concept of coping. Thus, most students interpreted stress as a demanding environmental condition (a stressor) rather that as a person's defensive reaction to it (Selye, 1956), and very few students mentioned coping strategies, or interactions between stressors, reactions, and coping strategies. However, perhaps the beginnings of an understanding of the interactional nature of stress can be seen in the considerable number of secondary and tertiary students who mentioned the number of stressors since this implies a possible imbalance between stressors and coping abilities.

The bulk of education research into stress has also concentrated on idenifying students' perceptions of stressors in their lives. This focus on stressors by both students and education researchers is at odds with both current conceptualisations of stress and with clinical practice in stress management which focuses on individual reactions and cognitive coping processes (Pelletier, 1977).

Q.2 Students' accounts of stressful experiences

There have been many claims that child and adolescent mental health education programs should be based on children's and adolescents' own perceptions and experiences of what troubles them.

The aim of question two in this study was to identify the stressors in students' lives. Students' emotional and physical reactions to stressors and their coping strategies were also explored in detail in two additional questions as part of a present study. These additional data will be the subject of a subsequent publication.

Table 1 lists the 12 stressors most frequently mentioned by students and the percentages of students mentioning them.

It can be seen from these data that the stressors identified by students are psychosocial rather than physical. Moreover students' stressors are not serious life crises such as those identified by Holmes and Rahe (1967) for adults and by Yeaworth et al (1980) for adolescents. As Lazarus and De Longis (1983) point out:

"One of the striking features of modern stress research is its preoccupation with dramatic events and severely taxing situations."

TABLE 1

STUDENTS' STRESSORS*

Stressor	Year 10 students(%)	Tertiary students(%)
Exams	22	35
School work/University work	25	24
Family	22	16
Teaching	-	16
Time pressure	-	16
Relationships with 'other people'	6	12
Boyfriend/girlfriend relationships	3	12
Social pressure	3	12
Driving a car	-	8
Extra-cullicula employment	11	-
Friends/peers	8	2

* Note: percentages are not additive.

It is difficult to interpret our students' perceived stressors in these terms. For most students, stress arises from the on-going activities and social interactions they participate in as part of everyday living. One student summed up this position as follows:

"Stress is sort of imposed on you day in day out, little things with life, they're the stress that I think is dangerous."

It is interesting in this regard to consider the responses of the secondary students who did not describe any stressful experiences. Twenty per cent of secondary students made comments like:

"Not really, just a few - kind of everyday things but nothing really."

"Not real stress. I may possibly have some but not real."

While these students were unable to articulate a particular stressor, they were nevertheless not denying the presence of stress in their lives. It seems likely that their comments reflect an intuitive understanding that the everyday hassles of life can be stressful. No tertiary students made statements like these, presumably because they could articulate these hassles. Thus, stressors such as "living in the city", "time pressure", and "doing too many things" were described by several tertiary students but no secondary students.

These data support the position of researchers such as Lazarus and De Longis et al (1983) that stress results from the chronic everyday hassles of life as well as from serious life crises;

> "the irritating, frustrating, distressing demands and troubled relationships that plague as day in and day out."

In terms of what these 'distressing demands' and 'troubled relationships' are for the students in this study, exams and school or university work are the most frequently mentioned stressors. These results are similar to those of other researchers who have investigated adolescents' stressors in different countries and using different methods.

Yeaworth et al (1980) found that "failing one or more subjects in school" was rated fifth on a scale of upsetting events, after "a parent dying", "brother or sister dying", "close friend dying", and "parents getting divorced or separated". Eme et al (1979) found that, after "physical appearance"; "careers", "grades", and "future schooling" were the most worrisome areas for adolescents. Yamamoto (1979) found that "academic retainment" rated third most upsetting after "losing a parent" and "going blind"!

These studies were all carried out in the USA using prepared scales of events which students were asked to rate. In an Australian study of the problems of adolescents, an open-ended questionnaire was used to rate adolescents' problems. "Educational adjustment" was found to be the most frequently mentioned category for boys, while "family adjustment" was the most frequently mentioned category for girls (Collins and Harper, 1974).

The combined cross-cultural data from these and the present study provide substantial evidence that the academic side of school life is the most distressing feature of adolescents' and young adult students' lives. This finding questions much of the conventional thinking in developmental psychology that peer and family relationships are major sources of stress for adolescents (Rutter et al, 1976).

CONCLUSION

Two of the primary aims of education about stress are to help students learn about stress, as well as helping them to cope with stress in their lives.

The majority of students in this study saw stress as a demanding environmental condition (i.e. a stressor), less frequently as the individual's reaction to it, and even less frequently as a complex and on-going process of interaction between the individual and his or her environment. Thus the individual and the interactionist aspects of stress need to be address and both aspects of stress, positive and negative should be included. This study highlights not only the areas in which students' understanding of stress can be broadened, but also it provides a rich source of students' experimental knowledge on which new learning can be based.

Stress management resources such as self-help literature, television programs, and community-based courses have been available to the adult population for several years. More recently stress management courses are being offered to college students in the USA (Allen, 1981). Researchers in the USA are now beginning to look at stress management units in high school health education programs (Richardson et al, 1983), but such courses are largely absent from Australian schools.

Given that stress is an inescapable part of modern life with considerable implications for individual and social health and well-being, knowledge about stress - its causes, effects, and means of management - should be available to all people.

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THE ATTITUDE AND KNOWLEDGE OF TASMANIAN SECONDARY STUDENTS TOWARDS ENERGY CONSERVATION AND THE ENVIRONMENT

Peter Davis

INTRODUCTION

Conservation of energy within our schools and colleges is a very real challenge, as many of these institutions are significant power users. Implementation of any energy management programme will only be successful if there is a sense of commitment on the part of the students to the aims and values of the programme, so their "awareness" and "attitude" must rate highly as factors to be taken into account.

This paper describes a preliminary study of the attitudes of Tasmanian secondary school students towards various energy conservation practices. The test instrument developed utilized the common three point behavioural scale described by Maddock (1978) to examine student attitudes on such matters as energy wastage, energy conservation, lobby groups and environmental effects. The study evaluated students' knowledge of various energy conservation measures such as passive solar house design, the use of insulation, and knowledge of sources of domestic energy usage.

The Environment Aspect

The classroom study of energy sources and methods of generating electrical power often, of necessity, leads to a discussion of the environmental impact presented by the various energy alternatives. This aspect is generally well served by text books, and so the emphasis in this study was specifically on conservation of energy at the domestic consumer level.

Work on student attitudes towards the natural environment has been carried out in Australia by Maddock and McDonald (1982). They developed two test instruments ACNE (Attitude to Conservation of the Natural Environment) and AEI (Awareness of Environmental Issues) which showed there was no evidence of any increasing trend in

the attitude scores over the years of high school education. There was also little relationship between attitude and achievement based on classroom tests in science (Maddock, 1979). The lack of any trend suggested that what is taught in the schools of the sample did not effectively modify the student attitudes towards conservation of the environment.

Eyers (1978) found that Australian students "don't know much", a result supported by the low mean obtained on Maddock and McDonald's (1982) "Awareness of Environmental Issues" scale, but that they generally had positive attitudes. Negative attitudes tended to occur where the object of concern impinges on the students' own lives. This becomes important in an assessment of actual energy conservation behaviour, as distinct from expressed attitude.

METHODS

Design of the Test Instrument

The Tasmanian Secondary School Certificate manual (Schools Board of Tasmania, 1983) has as one of its stated aims:

"Attitudes: Science studies shoud lead ... to the formation of soundly based attitudes to the conservation of our total environment".

"Energy" is listed as one of the five important themes of science, with "conservation of energy" being presented as a central theme around which energy topics revolve (Figure 1).

The test instrument consisted of four sections: "knowledge", "attitude", "behaviour" (recreational pursuits) and "identification" (background information). The emphasis was on obtaining information on energy matters reasonably "close to home" (such as domestic energy usage patterns), rather than assessing knowledge of world energy sources.

The Student Sample

The sample of students for this preliminary study (N=231) was obtained from four schools in the Hobart area. Both Government and Independent schools were represented, including an "all boys" and an "all girls" school. A full range of socioeconomic backgrounds were represented, including some students from country areas.

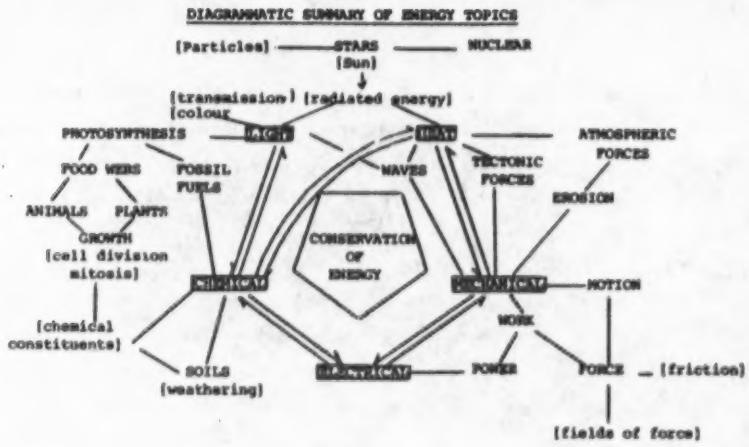

Figure 1: Energy Topics in School Certificate Science (Schools Board of Tasmania, 1983).

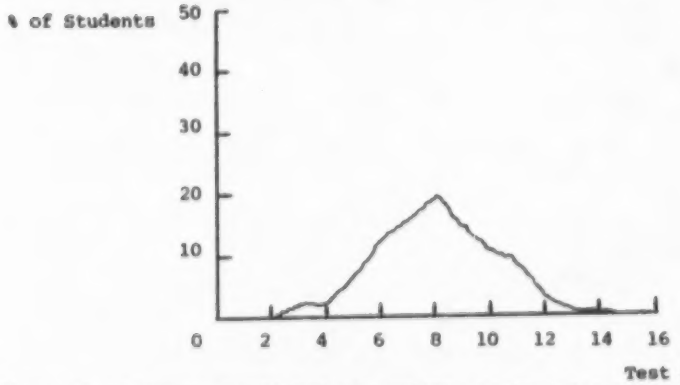

Figure 2: "Energy Knowledge" of Student Sample (mean score = 7.9, Standard Deviation = 2.18)

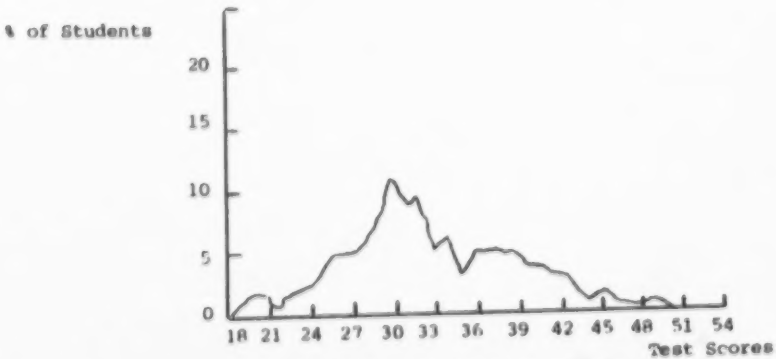

Figure 3: Attitude to Energy Conservation of Student Sample (Mean Score = 31.9, Standard Deviation = 5.54).

Figure 4: Responses to Question A5: (Attitude Index = 0.74):

If you saw a friend washing his car by connecting a hose to a hot water tap would you:

(1) Inform him of how much hot water he is wasting?
(2) Not be concerned at all?
(3) Think "what a good idea" and go home to do your own car?

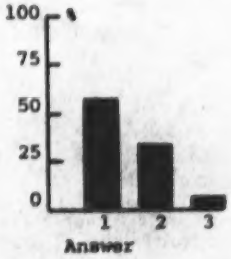

Figure 5: Responses to Question A10: (Attitude Index = 0.44)

In Tasmania recently there has been a great deal of debate on the development of Hydro Electric power schemes. The High Court eventually stopped the Gordon-below-Franklin dam from going ahead. What was your feeling on this?

(1) "No Dams"; i.e. pleased it was stopped
(2) Not interested
(3) Go Dams"; i.e. disappointed it was stopped.

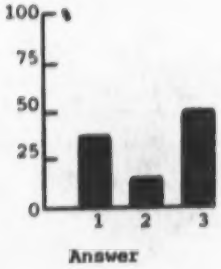

TABLE 1: Individual Item Analysis for Attitude Section

Item	Mean	SD	R	Item	Mean	SD	R
A1	1.65	0.61	0.27	A10	2.13	0.92	0.47
A2	1.64	0.78	0.37	A11	2.08	0.80	0.57
A3	1.71	0.66	0.26	A12	1.64	0.59	0.39
A4	1.86	0.60	0.57	A13	2.25	0.77	0.44
A5	1.49	0.63	0.46	A14	2.10	0.78	0.48
A6	1.25	0.54	0.24	A15	1.80	0.79	0.50
A7	1.29	0.60	0.33	A16	2.04	0.75	0.49
A8	1.79	0.86	0.42	A17	1.71	0.76	0.40
A9	1.81	0.77	0.49	A18	1.63	0.79	0.42

The questionnaire was administered to individual class groups from grades 8-10 at the four schools. These ranged from a "basic skills" grade 8 to an "advanced maths" grade 10. Students recorded their answers in numerical form on a separate answer sheet, which facilitated subsequent data transfer for computer analysis.

RESULTS

The results for the knowledge section of the instrument illustrated that the requirements of the Secondary Science syllabus with regard to knowledge of energy and energy conservation are not being met at the schools of the sample. The mean score for the total sample was 49%, supporting work by previous researchers (Eyers, 1978: Maddock and McDonald, 1982) which showed that secondary students' knowledge of environmental matters is not high.

The range of scores on the knowledge section is shown in Figure 2. A reasonably "normal" distribution resulted with no student scoring full marks or no marks.

The alpha coefficient for the attitude section of the instrument was 0.73. This is a very satisfactory result as it is generally accepted that for early stages of research an alpha of 0.50 or 0.60 is sufficient to establish basic premises (Nunnally, 1967). The "Pearson-Product Moment Coefficient" was used to evaluate the individual item reliabilities to enable selection of the most useful items for subsequent development of the instrument (Table I). Description of the items, and analysis of reasons for their success, or otherwise, is given in the next section.

In contrast to the work of Maddock (1979) the attitude section was designed so that a response of "1" represents an energy conscious, positive attitude, "3" represents a negative attitude and "2" represents the intermediate position. Thus it is the student with the lowest score on this section who possesses the most favourable attitudes.

The mean score obtained with the sample was 31.9 from a possible range of 18 the the positive end of the continuum to 54 at the negative end. This compares with a "neutral" result of 36. Figure 3 shows the range of attitudes to be widely spread, but clearly shifted to the left. Thus Eyer's (1978) comment, "They don't know much but their hearts are in the right place"" seems to be supported by this Tasmanian data on student attitudes to energy conservation.

DISCUSSION

The multichoice test is frequently utilized for "ease of marking" considerations, in which answers are simply marked "right" or "wrong". Valuable information is hence often missed. The computer marking package developed for this instrument has enabled various misconceptions to be pinpointed by examining the frequency of selection of alternative answers.

Knowledge

It was found that misconceptions on energy usage in the domestic situation were very prevalent. 40% of students rated lighting as using more energy than hot water, and 54% felt that switching lights off is more effective for saving energy than taking short showers.

Students knowledge of house orientations was low. 20% of students did not know which way their own houses face, whilst in response to question "K5", 25% of the Tasmanian students of the sample thought that houses should face east to take maximum advantage of the sun. Of more concern is the fact that 4.5% thought that south was the optimum orientation, while 18% did not know.

Difficulties were also encountered with questions on flooring materials. Only 37% realised that concrete is the optimum material for the floor of a "solar house", with 34% answering "don't know". In question "K11" only 13.5% successfully picked slate tiles as the most effective floor covering for a solar "direct gain" situation. 45% chose "carpet" as their answer, reflecting the very common misconceptions held concerning the function of floor coverings in a sunny room.

Attitudes

To assist in the interpretation of results on the "attitude section" of the test instrument a scaled "attitude index" is used. The attitude index has a range from 0 to 1.0, with "0" representing a most negative attitude, and "1.0" a completely positive attitude.

Student responses were generally positive to questions on hot water usage, switching lights off, setting heater thermostats and so on (e.g. Figure 4). A question on

options for a new house produced an attitude index of 0.85, as a surprising 78% of the students opted for full insulation, whilst only 14.5% chose the more moderate option of insulating the ceiling and installing an electric heater.

Several items were included to gauge reaction to various controversial energy-related topics. For example Figure 5 shows that a question on the Tasmanian "dam debate" indicated a marked split in student options, as with the community at large. Eighty six percent of students chose one of the extreme views, with a "negative" attitude index of 0.44 being obtained.

Other questions to obtain negative attitude indices (0.37 and 0.46) were those dealing with personal choices of transportation for commuting. In the question with A.I = 0.37 46% of students chose "driving your own car" as their means of commuting, compared to only 19% choosing a push bike. These results support the conclusions of West and Tapp (1980) that students will often have quite a positive attitude until the object of concern begins to affect them directly. Similarly, questions on the formation of an energy conservation club at school elicited a strongly apathetic response, with 64% of students indicating they would "ignore it", (attitude index = 0.56). The least interest in the idea was shown by students at the schools with highest mean socioeconomic background. This lack of sensitivity towards energy conservation by higher income earners is consistent with overseas research, which has shown that groups on low or fixed incomes are, of necessity, the first to adopt conservation practices in response to rising energy costs (Prosser et al., 1984).

Analysis of the student responses provided an indication of the likely reasons for variation in item usefulness (Table 1). The questions with the lowest reliabilities (A1, A3, and A6) dealt with the least "emotional" topics of the section, such as hot water tariffs and thermostat settings. It is clear that these questions did not raise strong feelings of energy conservation in the students. All other questions had R > 0.3, satisfying the normal criterion for a "useful item" (Nunnally, 1967).

ACTIVITIES

The final section of the test instrument aimed to evaluate the frequency with which the students engaged in various recreational activities, with the hypothesis being that people who regularly go bushwalking or visit Nature Reserves have an appreciation

of the natural environment which could be correlated with their attitude to conservtion in general, and energy conservation in particular.

The results obtained were rather disturbing. It was found that 24% of students of the sample "never" visit National Parks or Nature Reserves, and 35% "never" go bushwalking. A further 62% only "occasionally" visit National Parks or Nature Reserves.

These behaviours may be contrasted to the results found for television and movie watching habits. 78% of students watch television "quite often" or "all the time", but 25% claim to "never" watch television programmes on wildlife and conservation!

The results of this study showed some evidence of correlation between attitude to energy conservation and amount of bushwalking done ($r = 0.36$), but little correlation between knowledge and attitude ($r = 0.18$). This is in agreement with previous research in related fields (e.g. Maddock, 1979), and must be a source of concern for educators attempting to produce curriculum materials to enable the affective aims of the syllabus to be satisfied.

The effect of influences from outside the school arena is such that any new curriculum materials will need to be particularly effective if they are to have a positive influence on the formation of student attitudes towards energy conservation and the environment.

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AN EXPLORATION, USING AJZEN AND FISHBEIN'S THEORY OF REASONED ACTION, OF STUDENTS' INTENTIONS TO STUDY OR NOT TO STUDY SCIENCE

Keith Stead

As part of a comprehensive study which investigated sex and ethnic differences in students' Outlooks on Science (Stead, 1984), Ajzen and Fishbein's (1980) Theory of Reasoned Action was used to provide questionnaire data from particular groups of students in several New Zealand high schools about their intentions to study, or not to study science in subsequent years of their secondary schooling. This paper gives an outline of how the requisite questionnaire used in the study was developed and provides brief analyses of the sex differences found. The ethnic differences will be reported elsewhere.

RATIONALE

Ajzen and Fishbein have based their theory of Reasoned Action on the assumption that:

> "... human beings are usually quite rational and make systematic use of the information available to them. We do not subscribe to the view that human behaviour is controlled by unconscious motives or overpower desires, nor do we believe that it can be characterized as capricious or thoughtless. Rather, we argue that people consider the implications of their actions before they decide to engage or not to engage in a given behaviour. For this reason we refer to our approaches as a "theory of reasoned action".
>
> (Ajzen & Fishbein, 1980:5)

According to Ajzen and Fishbein'g Theory of Reasoned Action a person's intention to perform a behaviour (e.g. to study, or not to study, science) is made up from two relatively independent components:

(i) a person's attitude to that behaviour (e.g. "studying science") and,

(ii) their perceptions of what others will think about them performing that behaviour (e.g. "Most people who know me well think I should study science") - this perception may be called the perceived social standard.

A person's attitude to that behaviour is influenced primarily by a set of objective beliefs. The set of objective beliefs constitute all those personal opinions held by a person about the consequences of performing the behaviour in question. For example, a student may believe studying science will enhance his/her career opportunities, would provide intellectual satisfaction, and give a feeling of control in a technological environment. Such a student is likely to evaluate positively the action of studying further science at school. In contrast, the student who believes studying science is a waste of time because of its dubious relevance to his/her life, believes it to be difficult and suitable only for students who can afford university study, is likely to hold an unfavourable attitude towards further science study.

Associated with a person's objective beliefs that a given behaviour leads to certain outcomes are his/her personal evaluations of these outcomes (e.g. "studying science would enable me to obtain a place in a tertiary institution in the city but I cannot see myself as a tertiary student").

Similarly, a person's perceived social standard is influenced primarily by a set of social beliefs. These social beliefs are those associated with specific individuals or groups of people important to the person (e.g. "Dad thinks I should study science - Mum thinks studying science would be a waste of time").

Associated with these social beliefs are the person's motiviation to comply with the perceived wishes of significant people around him/her (e.g. "If my folks disagree, I usually do what Dad wishes, rather than Mum").

Ajzen and Fishbein use 'path analysis' (Wolfe, 1980) to assign relative weightings to the components of intention. This increases the explanatory value of the theory. For example, two Form 4 students, A and B, may express positive attitudes towards studying science at the Form 5 level and both may perceive social standards to be such that they should not study science any further. The outcomes of these conflicts between their attitudes and their social standards could be predicted by knowledge of the relative weightings each student gives to the components of intention. That is, the

different intentions of to study (e.g. student A) and not to study (e.g. student B) science at the fifth form level, would follow if student A's intention was determined primarily by attitudinal considerations, and if student B's intention was primarily under the control of his/her perceived social standard.

Finally, Azjen and Fishbein claim that although 'external' factors such as sex, age, social economic status, education, and various personality traits may well influence behaviour, they do so indirectly and only if they are related to one or more of the variables specified by their theory.

Of substantial interest to this study was the role of beliefs (both 'objective' and 'social') because it was suspected that (a) male students would have a more extensive set of objective beliefs about science than female students due to their greater informal exposure to scientific processes, principles, and products in their leisure time activities (Torrance, 1964; Belotti, 1975), and (b) girls would have more extensive set of social beliefs than boys (Saraga & Griffiths, 1981).

For many students in New Zealand schools, the decision whether or not to continue with a study of science is made during their second year at secondary school. This decision is made following often a total of only four or five secondary school terms of science so the influence of their sets of beliefs was seen to be of considerable importance.

The Theory of Reasoned Action also raised such questions as: Is there a 'characteristic' differential weighting of the attitudinal and social components for different student groups? Which people influence students' intentions (Parents? Science teachers? Peers? Potential employers?)? Are there identifiable stereotypes of science (and of people working in and/of studying science (held by each student group?

THE QUESTIONNAIRE

The data for the Theory of Reasoned Action analyses were produced by a questionnaire designed to provide values for each of the various factors shown in Figure 1. The development of this questionnaire occurred in two stages; an open-ended, preliminary stage and the 'closed' final stage.

(a) Stage one - the preliminary questionnaire. This first stage sought to collect a variety of student-held beliefs ('objective' and 'social') about the three branches of science usually taught in New Zealand secondary schools (biology, chemistry and physics) and about the influence of significant persons in their school science subject choice by providing a sample of 111 Form 4 and Form 5 students with an open-ended questionnaire.

For example, question one asked, "What are the advantages, for you personally, in studying science in the Fifth form?" Question six asked, "What are the reasons why you might not want to study Chemistry in the Sixth form. Questione nine directed the students to "Think hard about the people, or groups of people, who are most important to you in your life (perhaps relation, friends, teachers, possible employers, etc). List those who you believe would think science is an important subject for you to study.

(b) Stage two - the final questionnaire. Following a careful analysis of the responses made to the preliminary questionnaire, series of statements were drawn up which reflected the beliefs, attitudes and social influences indicated by the respondents. Each statement list provided data for a particular component of the TRA model and the final questionnaire format followed that of the sample questionnaire provided by Ajzen and Fishbein (1980). A 5-point Likert scale response was required for each item.

Each response to each item was scored on a one-to-five basis and entered into a computer file for subsequent linear transformation to provide the composite measures for each TRA model component. The data were analysed using the multiple classification and ANOVA programmes from the SPSS statistical package (Nie et al, 1975).

ANALYSES

The data displayed in Table 1 reveal that statistically significant differences occurred on each component of the TRA model. Boys expressed a stronger intention to continue with a study of science than did the girls; boy's attitudes were much more positive than girls'; the boys rated the set of objective and social beliefs more favourably than the girls; and they perceived significant people (refer to the social standard) in their lives to think they should study science more than did the girls.

TABLE 1

The results of the t-test analyses on the data collected from each component of the TRA model

	Intention		Attitude		Objective beliefs		Social Standard		Social beliefs	
	Mean	t-value	Mean	t-value	Mean	t-value	Mean	t-value	Mean	t-value
Boys (71)	3.82	2.40*	4.99	3.21**	4.11	2.67**	0.70	2.97**	3.0	2.32*
Girls (81)	3.27		2.46		3.45		0.12		2.69	

* = $p \leq 0.05$ ** = $p \leq 0.01$

Notes: 1. The 'objective beliefs' value was derived from a combination of the ratings given on the objective beliefs statements and the ratings given on the 'evaluation' of these beliefs.
2. The 'social beliefs' value was derived from a combination of the ratings given on the social beliefs statements and the ratings given on the 'motivation to comply' statements.

According to the TRA model the determinants of attitudes and social standards towards studying science are the salient objective and social beliefs within the conceptual system held by the students. These were explored by the preliminary questionnaire with the questions:

"What are the advantages, for you personally, in studying science in the fifth form?"

"What are the disadvantages, for you, in studying science, in the fifth form?"

Responses to these questions enabled eight specific salient object beliefs to be identified (e.g. 'I believed that obtaining scientific knowledge is worthwhile'). In order to arrive at a measure of the students' evaluation of these objective beliefs (as distinct

from mere agreement/disagreement), another response item in the final questionnaire required them to respond to these same objective items within the context of Form 5 science. Thus, a typical objective belief evaluation statement, to which the students responded was:

"I believe that by studying science next year in the fifth form I will be able to find a job when I leave school."

The responses to both components of these objective beliefs were scored, combined, and linearly transformed to provide a range of values from - 80 to +80 (negative values corresponded with unfavourable beliefs and/or low evaluations of them; positive values corresponded with favourable beliefs and/or high evaluations of them). The statistically significant ($p < 0.05$) differences (Table 1) indicated the boys tended to agree with the set of objective beliefs more, and/or associated them more closely with Form 5 science, than did the girls. The boys' greater informal, out-of-school experience with scientific phenomena may be implicated in this finding.

Similarly, the social standards were determined with a set of social beliefs, or beliefs about specific people, and the extent of the students' motivation to comply with these people, identified within the preliminary survey by the questions:

Think hard about the people, or groups of people, who are most important to you in your life (perhaps relations, friends, teachers, possible employers etc).

- List those who you believe would think science is an important subject for you to study. Indicate who they are after their name. E.g. Brian (best friend).

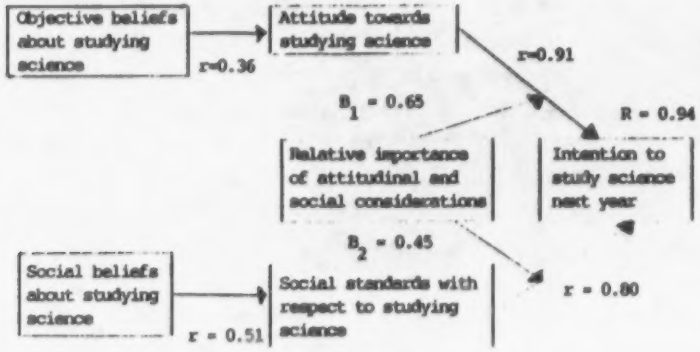
- List those who you believe would think science is not an important subject for you to study. Indicate who they are beside their name.

In a fashion comparable to that used in determining the measure of the students' objective beliefs, two items referring to specific people, or groups of people, were developed for the final questionnaire. For example, the students were instructed to indicate their strength of their agreement or disagreement (on a five point scale) that 'My father thinks I should study science next year in fifth form.' The motivation to comply component of the social belief was determined by the students' responses to the statement, 'I usually do what my father wants me to do' (again scored on a five point scale with respect to agreement/disagreement).

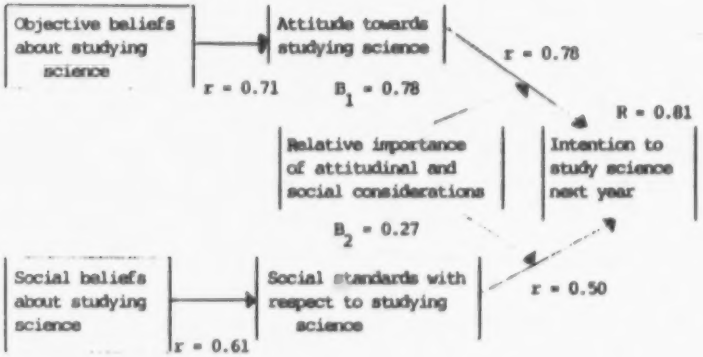
FIGURE 1

TRA models illustrating the relationships between Form 4 students' objective beliefs, attitudes, social beliefs, social standards, and their intentions to study science in Form 5

(a) Form four girls



(b) Form four boys


Objective beliefs about studying science
r = 0.71
Attitude towards studying science
r = 0.78
B1 = 0.78
R = 0.81
Relative importance of attitudinal and social considerations
Intention to study science next year
B2 = 0.27
Social beliefs about studying science
r = 0.61
Social standards with respect to studying science
r = 0.50

The two social belief components were combined to produce scores with a possible range of value from -80 to +80 (negative values correspond with student perceptions that the people identified did not want them to study science in the fifth form and/or expressions of non-compliance with those people would want them to continue with a study of science, and/or compliance with those people who would not want them to continue with a study of science; and vice versa). Once again, Table 1 reveals sex differences. Boys did perceive specific people to encourage them to study science in form 5, and/or tended to comply with these people, more than did the girls. The influence of sex role stereotyping and the image of science being a masculine pursuit could be suspected to be a factor in forming such perceptions.

Within the TRA model, the attitudes and social standards are the immediate determinants of intention. Therefore, a multiple correlation between intention (the dependent variable) and students' attitude and social standard would be predicted to be high. This was shown to be so. Figure 1 shows these data; R = 0.81 (boys) and R = 0.94 (girls). Thus, students who had positive attitudes towards studying science in Form 5 and who believed others thought they should study science, intended to be successful in their next year's science studies. The converse also would apply.

Although the analyses, to this point, show that both social standards contribute significantly to the students' intentions to be successful in science in the fifth form, it is interesting to note several differences in the relative contributions to intention made by each student group. Estimates of relative importance may be obtained by considering the regression coefficients (beta weights) associated with each component and the dependent variable (see Figure 1).

For boys, these values were 0.78 and 0.27 for the attitudinal and social components, respectively; for girls, they were 0.65 and 0.45. Therefore, within both student groups, the attitude component was considered to be the more important determinant of intention than was the social standard. This finding, that the contribution of the girls' social standard to intention was a greater relative importance than that of the boys', supported the observation that, during informal discussions conducted with the students, it was more often the girls, rather than the boys, who mentioned the influence of others on their thinking.

"Nana believes I could do without science as she thinks it's not important - I'd be better doing something like Home Economics, clothing, etc". (Form 4 girl)

"Friends would think you were crazy (if you took science) 'cos it's so hard!" (Form 4 girl)

The predictive utility of ascertaining the students' objective and social beliefs is assessed by noting the extent of the correlation between the objective beliefs and the attitude components, and that between the social beliefs and the social standard components.

For boys, the correlation between the objective beliefs and the attitude component was high ($r=0.71$) while for the girls it was still positive but relatively lower ($r=0.36$). This would suggest that the determinants of attitude differ between the sexes. That is, girls' attitudes appeared to be determined by factors other than just their objective beliefs about science, whereas boy's attitudes appeared to be determined by their objective beliefs. One explanation for this could be that as boys generally have a wider range of out-of-school science experiences than do girls and so, have formulated a greater range of objective beliefs about science and, in evaluating them, are more likely to express positive attitudes.

The resultant correlation between the social beliefs and social standards did not show such marked between group differences: $r= 0.62$ (boys); 0.51 (girls). Thus, it can be simply said that the responses to the set of social beliefs appear quite strongly predictive of social standard responses.

Item analyses of the statements, which comprised the measures for the attitude, the social standard, the objective and social beliefs, and the evaluation and motivation components of the TRA, showed boys to anticipte their Form 5 science studies to be more interesting, worthwhile, necessary, easy, and useful ($p<0.01$) than the girls. As well as themselves, the boys believed that their parents, friends, teachers, and possible employers, would think the boys should study science in Form 5. The girls did not perceive these people to think the same about themselves (the girls) and form 5 science. Marked sex differences were noted for the students' mothers ($p<0.01$), teachers ($p<0.01$), and possible employers ($p<0.001$); the latter probably reflects the boys' perceived career application of science.

This outline and brief analysis has been presented to draw the attention of the interested reader to possible applications of the Theory of Reasoned Action in the field

of Science Education. Research in the affective dimension is bedeviled by loose terminology and a bewilderingly wide array of 'instruments' which often have little theoretical rationale for their existence. Ajzen and Fishbein's 'theory' provides both an instrumental technique for collecting requisite data and an explicit rationale for allowing for the analysis, description, prediction and application of the findings s generated.

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SCIENCE EDUCATION - TIME FOR A PARADIGM SHIFT?

John Edwards

INTRODUCTION

Since the seventeenth century our culture has embraced the mechanistic conceptions of Newton an Descartes. Newtonian physics and the Cartesian belief in the certainty of scientific knowledge permeate our belief systems and knowledge structures. They have also led to the dominance of reductionism, to an emphasis on hard science and hard technology, and to a spiritual vacuum in our mainstream culture.

For over fifty years now there has been growing a realisation of the damaging limitations of the Cartesian-Newtonian world view. Indeed there are now many who believe that a paradigm shift is essential to our survival. Capra (1983) discusses in detail the numerous manifestations fo the crisis in our society. He regards it essentially as a crisis of perception and describes what he sees as the present shift to a holistic and ecological, system paradigm.

SHIFT IN PHYSICS

One shift is attributable to Einstein who unlocked a Theoretical door through which other scientists could then pour to pursue knowledge.

Anothe major twentieth century developement was the experimental investigation of atoms. But search for fundamental building blocks of "time-honoured theory" proved frustrating since, at the subatomic level, solid objects of classical physics dissolve into wave-like patterns of probabilities.

The particle-wave duality of subatomic particles was difficult for physicists to accept until it was realised the the terms "particle" and "wave" refer to classical

concepts which are not fully adequate to describe atomic phenomena. These "particles" are either particles nor waves; they have no intrinsic properties independent of their environment. Their properties, particle-like or wave-like, depend on the apparatus with which they interact.

Physicists, following Heisenberg, had to abandon the classical idea of scientific objectivity: scientific research actually involves a participating, conscious, human observer. Consequently, there are no objective properties of nature independent of the human observer. As Capra (in Wilber, 1982) observes: "research is pursued within the context of a certain paradigm, a broader vision of reality, which involves not only concepts but also values. And therefore science is always implicity subscribing to a set of values, and scientists are not only intellectually responsibile for their research but also morally responsibil".

A LINK TO NEUROPHYSIOLOGY

Pribram (in Wilber, 1982) has proposed a new conceptualisation of brain functioning. His holographic model of the brain is supported by the finding that at one stage of processing the brain performs its analyses in the frequency domain. This takes place in the junction between neurons. So the brain is not seen as storing individual bits of information in particular places, like a card index, but as storing holographically. Pribram believes this explains why visual memory cannot be precisely localised in the brain. Any piece of a hologram will reconstruct the entire image. Similarly, specific memory traces are spread over a sufficient expanse of brain to ensure that they are resistant to brain damage. As well as explaining convincingly a number of such neurophysiological puzzles, and fitting an impressive and growing range of research data, the model also links closely to physics and new conceptualisations of reality.

A major, popular, element in Pribram's model is that it accounts for transcendental experience, paranormal events and common "perceptual oddities", as well as the "respected" aspects of brain functioning.

CAPRA'S HOLISTIC PARADIGM

Capra (1983) proposes a new holistic paradigm, based on an awareness of the essential interrelatedness and interdependence of all phenomena - physical, biological,

psychological, social and cultural. His systems view looks at the world in terms of relationships and integration. Systems are integrated wholes whose properties cannot be reduced to those of smaller units. Instead of concentrating on basic building blocks or basic substances, the systems approach emphasises basic principles of relationship and organisation.

The activity of systems involves a process known as transaction - simultaneous and mutually interdependent interaction between multiple components. Systemic properties are destroyed when a system is dissected, either physically or theoretically, into isolated elements. Although we can discern individual parts in any system, the nature of the whole is always different from the mere sum of its parts.

Capra argues that reductionism and holism are complementary approaches which, used in proper balance, should help us obtain a deeper knowledge of life.

STRUCTURE TO RHYTHM

The systems approach has shown that living organisms are intrinsically dynamic and that ordered structures arise from rhythmic patterns. Such patterns seem to be manifest at all levels. "Atoms are patters of probability waves, molecules are vibrating structures, and organisms are multidemensional, interdependent patterns of fluctuations. Plants, animals and human beings undergo cycles of activity and rest, and all their physiological functions oscillate in rhythms of various periodicity." (Capra, 1983).

The rhythmic patterns that characterise an individual human being are different manifestations of the same personal rhythm, an 'inner pulse' which is the essence of personal identity.

The holographic models discussed earlier also clearly fit this pattern. Similarly current models of human communication (Leonard, 1981) emphasise the synchronisation and interlocking of individual rhythms. Also, at rare moments in our lives, we may feel that we are in synchrony with the whole universe. These transcendental experiences are achieved in a wide range of ways by different people.

IMPLICATIONS FOR SCIENCE TEACHING

In this short paper I only wish to touch briefly on some of the more obvious implications for science teaching.

The overemphasis on Newtonian-Cartesian approaches in science and in science classrooms has resulted in the downplay of intuition. These intuitions usually come as diffuse wholes and much scientific and philosophical research is working back from an intuitive conclusion adding the logic or proof steps afterward. This is common among famous scientists. For instance, Einstein experienced relativity theory before he formulated it. Bohr experienced quantum mechanics before he formulated them.

We neither discuss the role of intuition in scientific discovery nor encourage its use by students. With curricula packed full of material there is little time for students to give prolonged attention to any problem or to reflect on any matter. Also, for most students, if they are not convinced that something is possible then it will never eventuate. The impressive results for suggestive-accelerative learning techniques based on Lozanov's theories (Lozanov, 1977) show what can be achieved when learning apprehension is overcome.

Another manifestation of the Newtonian-Cartesian approach is the overemphasis on measurement and quantititave statements. According to Laing (1982), hardly anything has changed our world more during the past four hundred years than the obsession of scientists with measurement and quantification.

As Laing (1982) puts it "Out go sight, sound, taste, touch and smell and along with them has since gone aesthetics and ethical sensibility, values, quality, form; all feelings, motives, intentions, soul, consciousness, spirit. Experience as such is cast out of the realm of scientific discourse."

Can there be a science that is not based exclusively on measurement; an understanding of reality that includes quality and experience and can yet be called scientific? Capra (1983) believes this is possible: "I am prepared to call any approach to knowledge scientific that satisfies two conditions: all knowledge must be based on systematic observation, and it must be expressed in terms of self-consistent but limited and approximate models. These requirements - the empirical basis and the process of model making - represent to me the two essential elements of the scientific method.

Other aspects, such as quantification or the use of mathematics, are often desirable but are not crucial." While one may not accept Capra's thesis, the discussion of such issues is important for science students. More widespread questioning of the current paradigm and exploration of the new should be part of school science.

Pribram suggests that children should learn about paradox in primary school since new scientific findings are always fraught with contradiction. The success of Lipman's (1982) "Philosophy for Children" program at this level is an encouraging start. It is often the "best" students who are hardest to open up.

The valuing of "softer" data in science classrooms has been encouraged to some extent by the increasing emphasis on environmental concerns. However, the exploration of pedagogical strategies in science is still mostly conservative. I have used Brecht's play "The Life of Galileo"; jam sessions in the science laboratory making up "science" songs; "Deep voices", the songs of the humpack wales; discussion and exploration of psychic phenomena; and a range of other techniques, in attempts to value and access other ways of knowing. While such techniques have been very productive for students, they are sporadic. Laing's "shopping list" above represents a strong challenge to curriculum developers and to trainers of science teachers.

Pribram predicted in 1977 that the soft sciences of today will be the core of hard science in 10 to 15 years, just as cognitive psychology, once considered soft, took precedence over behaviourism. While his time-scale may be out there is no doubting the exploding interest in these areas among scientists, the general community, and school students.

Capra (in Wilber, 1982) makes a strong claim in this respect: "I believe that at the present level of science it is already apparent that mysticism, or the perennial philosophy, provides the most consistent philosophical background to all scientific theories. And I challenge anyone to show me a different philosophical tradition that is more consistent with modern physics, biology and psychology."

CONCLUSIONS

The science we teach in schools, and most tertiary institutions, is only telling one view of reality. The need to generate a balance between reductionist and holistic

approaches is great. This not only has implications for science curricula and the training of science teachers, but also for the pedagogy of science, and for science education research. The view of what is acceptable, what is valued, and how learning is negotiated, needs to be broadened. We need to pay closer attention to relationships in what we teach, how we teach, and what we research.

It is problematic whether the holographic model will change our conceptions of reality. Pribram's work has opened up exciting new insights into memory and learning, but already the range of "applications" of the model is causing concern, and often the differences between a metaphor, a model, and the real world are overlooked. The work of Pribram and Bohm is most significant in that it has, from a scientific base, opened up alternative realities to the Western mind. The resulting arguments which rage in the academic literatures are an encouraging sign.

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THE IMPORTANCE OF CONTEXT IN EDUCATIONAL RESEARCH

Richard White

Research before the late 1970s amazes us by its naive neglect of the effect that prior knowledge has on new learning. This neglect occurred despite the writings of theorists within the dominant experimental paradigm of the period, such as Ausubel (1968), who described how new knowledge is assimilated by old with consequent changes in both; and Rumelhart, Lindsay, and Norman (e.g. Lindsay & Norman, 1972), who identified mechanisms such as tuning of learning; let alone the ideas of people outside that paradigm such as Piaget who wrote so much about beliefs and their development in children. Also ignored were the singular contributions of solitary scholars such as Oakes (1945), who probed individuals' understanding of scientific concepts and phenomena at a time when virtually everybody else was conducting mass experiments. When, in the late 1970s, researchers did become alert to the impact prior beliefs have on new learning, a revolution followed in their work which can readily be traced in the successive volumes of Research in Science Education. This revolution is still in progress. There is, however, another factor with as much or even greater potential for promoting revolution which has been overlooked by theorists as well as researchers. That factor is the context in which learning occurs. My purpose here is to suggest reasons for the neglect of context, to establish its importance in research, to delineate its features, and to describe some ways in which it might be taken into account in research.

WHY CONTEXT HAS BEEN NEGLECTED

While it is not possible to establish definitive reasons for theorists' and researchers' neglect of context, speculation about them is useful because it can indicate which aspects of context are important and because it may even identify other factors that presently remain hidden. I can suggest three sources that may be responsible for the neglect of context. There are the dominance of the scientific paradigm, the nature of the people who do research in education, and the stability and uniformity of schools.

The Scientific Paradigm

This has been the century of science and technology. In both peace and war science has pervaded all people's lives, its power is universally recognized, and so it is natural that its mainspring, scientific method, is valued. A feature of scientific method is the search for universals. It is assumed that phenomena will be consistent, for example that the laws of mechanics hold throughout the universe or that zinc reacts with hydrochloric acid at any time of day in any country. We recognize that there are boundary conditions for many phenomena, but often leave these unstated. We do not, for instance, say that the acid has to be above freezing point. In other words, we generally do not describe the context for which the statement holds true. Indeed, it irritates us when statements have to be qualified by setting out the conditions, and we like to generalise from limited cases to all situations. A classic instance is the application to all people of the conclusions reached by Freud from his study of turn-of-the-century upper-middle-class Austrian Jews. The history of psychology reveals many examples of the search for universals, a search which often involved simplifying and making artificial the context. Instances are memory experiments in which nonsense syllables were used in order to remove the influence of different amounts of knowledge, and breeding of animals for maze-running tasks so that genetic differences and prior experience could be controlled. Conclusions from these artificial studies are often taken to apply to all learning.

The Nature of Researchers

Educational research, through the 1950s and the 1960s at least, was dominated by psychologists who were imbued with the scientific paradigm. Another characteristic of these leaders was that few, if any, had spent any appreciable time as teachers in primary or secondary schools. Skinner, Bruner, Gagne, and Ausubel were experts looking at school from outside rather than former practitioners reflecting on their experience. Although their intellects enabled them to discover and report important things about learning, they did not have the experience which would have made them as appreciative as practising teachers are of the complexity, the incessant variability, the interactedness of the classroom. Consequently there is little in their writings that concerns the behaviour of groups. They describe learning as a process occurring in an individual, as indeed it is, but the point is that their individual is essentially isolated, not infuenced by other learners. They do not write about the circumstances in which the individual is placed: what society, with what values; what physical conditions; what

companions, their ages and interests. Their learner is not only isolated but floats in a neutral environment, and we are led to infer that the principles the theorists set out apply universally, unaffected by context. Teachers, however, know that what one child does affects and is affected by the others in the class, and that what happened between students before the lesson can have more effect on its course than anything the teacher does in it.

Teachers, or ex-teachers, who do research have their own limitations. They are moulded by their experiences within the school system. Secondary teachers predominate among researchers because for a long time in most countries primary teachers were not university-trained. Secondary teachers tend to think of schooling as subject-based and not concerned with the development of the whole child across all knowledge and from early years to adulthood. The very existence of ASERA reflects that view. It is a subject-related association. This narrowing of conern may be another influence inhibiting appreciation of the importance of context.

Stability and Uniformity of Schools

The third factor which may have been responsible for the neglect of context is the lack of variation of schools, both in place and time. As someone observed, it is difficult for fish to contemplate a world without water, and so it has been for us to imagine a world in which schools differ significantly. The attention paid to Summerhill in the 1950s and 1960s tells us more about the mass of schools than was realised at the time. They were remarkably similar to each other. Since the context did not vary significantly from school to school, there was no need to consider it in research.

One check on the accuracy of the foregoing explanations is to see whether those conditions have changed sufficiently to explain why it is now possible to recognize the importance of context.

The first speculation concerned the success of science and its search for universal principles. Doubts about the value of science and technology became common around 1970, when there was much social unrest in many countries. While it may not be possible to tie this unrest directly to the Vietnam war, there was plenty of revulsion then against the massive destructive use of industrial power and a sharp rise in concern for the environment. "Greenies" groups were rare and silent until the 1970s. These movements mark an appreciation of the inter-connectedness of human affairs, of how

social questions are rarely simple and have multiple sides. It became clear that a scientific advance can have a social cost, and that what may be accepted as good inone situation may be seen as deleterious in another. That is, that the worth of an innovation depends on its context and on how it is perceived.

Perhaps the same appreciation of the complexity of affairs was responsible for people's impatience with the contributions of rat psychology, behaviourism, and nonsense-syllable studies to the understanding of human behaviour. Educationists rejected these contributions, probably because they saw them as over-simple, excluding too many important factors to be relevant to their concerns. Once that was appreciated, eventually the question had to be asked, what are these important factors? Although among the first to be recognised were the characteristics of the human individual, the purposes, beliefs, and values which we began to look at in the present revolution, eventually context, too, had to be discovered.

The dominance of psychologists waned in the 1970s. The authorities of the 1960s and 1970s, Skinner, Ausubel, Bruner, and Gagne, were not replaced by a similar small group of leaders. Perhaps because of social unrest, perhaps because of the opportunities provided by a rich economy, teachers began to enter research degree programs in the late 1960s and 1970s, not only in America but also in Australia, New Zealand, and Europe. These teachers did not reject the ideas of the psychologists, but extended them as they recognised their limitations. Skinner's behaviourism was seen to be simplistic, appropriate for some aspects of the learning that occurs in schools but by no means a large fraction. Ausubel wrote about one form of knowledge, verbal information; and Gagne about another, algorithmic skills. Although many people might have thought Bruner and Piaget had more relevance to schools, even they were too limited. The researcher-teacher's recognition of the limitations of the psychologists' ideas makes it possible to appreciate the effect of context.

The less serious limitation of researchers to those with experience of secondary schools is disappearing also. Scholarship is on the rise in primary teachers colleges through their development as liberal arts colleges of advanced education. There is a surge in the qualifications of their staff and in what is expected of them. Not long ago hardly any members of the Australian Association for Research in Education were from CAEs, but now there are many; the same applies to attendances at ASERA. Many of the trainers of primary teachers have become researchers as well. Enrolments at Monash University reflect this trend, with substantial numbers of primary teachers in higher course work and thesis degrees.

The uniformity of schools is still remarkable, but is breaking down. "Alternative" schools - the name itself reveals the uniformity of the times - began to flourish in 1970, and it became possible to compare contexts.

This reflection indicates that the three reasons I advance for the neglect of context may be correct.

FEATURES OF CONTEXT

I propose that it will be useful to think of context as having three major features, those to do with physical conditions, the people involved, and the social conditions; and further, that it is important to distinguish between real and perceived, or objective and subjective, aspects of context.

Physical Conditions

Physical features of context concern place and time. What happens in any situation can be affected by whether the setting is in school or not, by room size and shape, furnishings, noise level, and temperature. On a very hot day people may be so listless their attention to a new program flags and the program is judged ineffective, when in other conditions it could have been successful. This influence of context on the evaluation of a program is not overcome by random selection and allocation of people to treatments, or by having identical conditions for groups being compared, because under one set of conditions such as distracting noise or high temperatures the groups may perform equally indifferently, while under another set one of the groups may be able to demonstrate superiority. As an analogy, the research question of whether McEnroe is a better tennis player than me might be answered differently than it would under standard conditions if we played in a blizzard on an off-shaped court covered with golf balls. Less facetiously, we see that conditions of tennis such as grass or clay surface favour one player or anothr, and so it can be with educational programs.

Time can affect performance. It can make a difference whether the research took place early or late in the day, the week, the term, or the school year. Early in the year, for instance, social patterns may be more fluid and formal and informal rules of behaviour less established, and so an innovation may have more chance of success than it would later.

People Features

Many characteristics of people can readily be imagined to have the potential for influencing behaviour, and hence for affecting the results of research: the number present; their ages, especially the range of their ages; the proportions of males and females, and the sex of principal figures such as the researcher or teacher; the homogeneity or diversity of the participants; and the pattern of their inter-personal relations. The effect of the latter is demonstrated by Emery (1984), in a year-long study of the behaviour of grade 6 children in a program designed to enhance the quality of their artistic production. Some of the children were conformist and unimaginative, until one day the two dominant children in the class were absent. Then the repressed ones changed their performance and showed some creativity. Thus the presence or absence of particular people, and the patterns of relations that follow, can lead to different conclusions about the effect of a new teaching program.

Social Features

The social context in which research is done seems likely to have a stronger effect on the results than the physical conditions or even the nature of the participants. The sorts of feature to include here are the values of the participants, their institution, and their society; the types of behaviour and situations that they can understand and are prepared to tolerate; and the organizational structure they are in and its patterns of authority.

Baird's (1984) six-month effort to change the learning styles of grades 9 and 11 students illustrates the influence of social features. He tried to get the students to be more responsible for their own learning, and to exercise more control over the conduct of lessons. As part of this they were encouraged to ask questions when they did not understand. Although Baird produced some change, it was not easy. One way in which a social factor inhibited what he was trying to achieve is illustrated by what students said about asking questions: (Grade 9) "I don't like asking teachers questions. I feel embarrassed... I want to ask questions but I just can't... I might ask them a silly question, and they might think 'Oh! You should know that by now." (Grade 11) "I don't ask questions because I get my head chopped off... He doesn't do it to be mean, but you can't ask him too many questions at one hit." Asking questions was not an act that the social context encouraged. Thus we can imagine a study which led to the conclusion that "encouraging students to ask questions does not produce better learning", a conclusion which might hold in this social context but not in another.

It is my impression from watching Baird's work, from watching Northfield and Gunstone teach at Monash High School, and from watching teachers at Laverton High School, that attempts to make students more responsible for their own learning run into difficulty because of the context that the students perceive for schooling. The purpose is seen as preparation to pass examinations, with the goal of being better prepared for getting a job (not necessarily for doing it better). Teachers are seen both as authority and as authorities. Schools belong to the teachers, and the students have no share in them. These perceptions lead students to reject the idea of learning how to learn better as a goal in itself. Useful work is seen as taking notes, not as thinking or discussing.

It is not hard, though, to imagine other contexts in which Baird's efforts, and the other instances, could have been either more, or less, successful. The Thai schools I saw in 1975 would, I imagine, have been even less receptive contexts for an attempt to make students reponsible for their own learning. I believe there have been marked changes since. On the other hand, a context in which there was no external examination controlling entry to tertiary institutions and a society which rewarded culture and learning more directly and overtly should be more fertile ground.

IMPLICATIONS FOR RESEARCH

Since context can determine the behaviour of participants and hence the results of a study, it needs to be taken into account in the planning and the reporting of research.

Reports of physical and people features is easily done, provided editors of journals are prepared to grant the small amount of additional space that would be required to list the details. The information is simple to collect, and generally involves direct measures: time and place and numbers of people and so on do not require the construction of elaborate tests. An implication of this is that researchers should keep an events book, a diary of occurrences that might have influenced the behaviour of participants.

An example follows of the sort of report that might be made about the physical and people features of context.

> The two treatment groups were in three rooms each. The three rooms for the experimental group were standard classrooms of 9.7 m x 7.6 m, with five parallel

columns of six single tables with individual chairs, facing the teacher's table and blackboard. For the control group two rooms were of that type, while the third was smaller (9.0 m x 6.5 m) with three columns of five double desks with fixed bench seats. Lighting conditions were similar in all rooms, and adequate for good reading. Noise levels were low throughout the experiment, except on day 3 for one experimental group when workmen caused distraction for 10 minutes by hammering in the corridor outside the room. Temperatures were moderate, in the range 14°C to 23°C.

The distribution of students among the rooms was:

Room	Boys	Girls	Age Range	Note
	Experimental			
A	12	15	12.2-13.7	Boys tended to be at back
B	13	15	11.11-13.9	Boys tended to be at back
C	16	10	12.0-13.11	Girls at back and left of room
	Control			
D	12	17	12.0-13.9	Boys tended to be at back
E	16	14	12.3-13.5	Girls tended to be at back
F	10	10	11.9-13.2	Smaller room. No mixed sex pairs in double desks

Social features are more troublesome, because they are difficult to determine and often will require subjective measures. Researchers will make their own subjective assessment of the social context, saying for instance that it was a competitive, achievement-oriented system with different values for boys and girls, or whatever, but we must consider that there is also the appreciation of that social context by the subjects of the research. They may not see it in the same light as the researcher at all. This is true, too, for the physical and people aspects. What appears primitive, crowded, and noisy accommodation to the researcher may seem luxurious to the subjects. Both views need to be reported in order for better understanding of the research. Therefore, in planning the study, researchers should not only have a list of social aspects for which they are to record values, but they should also devise ways of obtaining their subjects' views of the context. They might use interviews or questionnaires to elicit reactions to the physical surroundings, or the understanding of the purpose of the study, degree of interest in it, and willingness to co-operate. The sorts of questions that might be asked are:

Was the purpose of the investigation explained clearly to you?

What was the purpose?

Do you think it was a sensible purpose?
Did you try hard to learn the passage?
Was it important to you to do well on the test?
Do you think that the other students tried harder than you?
Did anything happen to distract you?

I know of no studies that include such measures. Perhaps this is another consequence of rat psychology, which has led us to behave like vets rather than medicos. Vets are handicapped by being unable to get reports from their patients. We would think it odd behaviour for medicos to ignore all that their patients can tell them, yet we restrict ourselves to a narrow set of responses, usually controlled by tests we have set, which do not extend to perceptions of context.

As well as recording context and assessing perceptions, researchers should seek to make replications in widely different contexts, so that if the same result is obtained consistently the generalization that follows can be accepted with confidence. An early example of this is Linke's (1974) repetition in several Australian states and in New Guinea of White's (1974) hierarchy validation study. Another is the work initiated by Nussbaum and Novak (1976), probabing young children's beliefs about the shape of the Earth. The initial study involved interviews with second graders in the United States. The context for the second study (Nussbaum, 1979) changed: it was carried out in Israel with fourth to eighth graders, and a mass-administered pencil-and-paper test was used instead of individual interviews. The results were consistent with those of the first study, as were those of the third (Mali and Howe, 1979), in which the context involved a different culture: children in Nepal were interviewed. A useful next step would be to replicate the study in a Southern Hemisphere country, so that the effect of upbringing on the "underside" of the Earth can be determined.

A broader example is the work on scientific conceptions. The strength of this work is the consistency of the observations made by people in many countries, through many techniques, on many principles and phenomena. The coherence of the work of Osborne, Hewson, Arons, McDermott, Clement, Champagne, Brumby, Driver, Novak, Andersson, Tiberghien, Gunstone, Erickson, and many others, using interviews, prediction-observation-explanation, Venn diagrams, and concept maps to probe understanding of mechanics, heat, light, electricity, animal classification, evolution, the nature of matter, and so on, in Australia, New Zealand, Canada, Britain, France, Sweden, South Africa, the United States, and elsewhere, shows that the results are

effectively independent of context. No doubt that is encouraging, but suppose that the results had differed from country to country, or topic to topic. That, too, would have been useful as we sorted out the factors in context that were responsible. A neat example is provided by the studies that Mori and others carried out in Japan and Thailand. The first of these (Mori, Kitagawa, and Tading, 1974) concerned conceptions of time. Thais tended to think of time as circular succession, Japanese in Christian schools saw it as having a beginning and an end, and Japanese in public schools thought of it as linear but infinite. All three views can be traced to religious contexts. The second study (Mori, Kojima, and Tadang, 1976) showed that Thai children's judgments of instantaneous speeds were more advanced than those of Japanese children, possibly because of differences in the language context. Thai, like English, has separate words for early and fast, and for late and slow, but these are not distinguished in Japanese.

My final suggestion for designing research in order to accommodate context is to vary physical conditions, either systematically or randomly.

Systematic variation amounts to including context as an independent variable, with as many levels as one can afford to use. The influence of context can then be determined directly. The disadvantage of this procedure is that costs in time or materials or people will mean that normally only two or three types of context can be included.

Random variation of contexts might consist of running testing or learning sessions at all times of the day or week, in many locations, or using many different approaches in interviews rather than a standard form. While this is tedious, and has the disadvantages of burying rather than uncovering the effects of context and of increasing the variance between people and thus of reducing the power of the experiment, it does increase the external validity. The conclusion will be more firmly established than it would for an experiment conducted in a limited context, as most of our experiments are.

Of course it will be difficult to implement the recommendations I have made. They will add to the complexity and cost of research. Will we get anything else in return, besides greater external validity for our conclusions? I believe we can expect another, and potentionally far more important return: just as the revolution that involved us in probing understanding of scientific concepts led to surprising insights into the process of learning, so could consideration of context. The influence of research on practice took one leap forward with the first revolution; it would take another, and greater, one with the second.

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USE OF CONCEPT MAPS IN ASSESSING THE VALUE OF A COMPUTER-BASED ACTIVITY IN BIOLOGY

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INTRODUCTION

Microcomputer hardware and software are increasingly avaiable as resources for use in science teaching. As a consequence, major determinants of the use of computer-based activities in science teaching are shifting from logistic considerations, such as access to hardware, to educational considerations, such as the assessment of the contribution of computer-based activities to students' conceptual develoment. This change should be paralleled by a corresponding shift in software evaluation. Evaluation can focus on the software itself or it can focus on its use (Wade 1980). In the former case, the software package is usually evaluated against a long checklist of internal attributes such as use of colour, text spacing on screen, use of reverse video. Such evaluation generally leads to a final overall numeric or descriptive grading for a package. In reality, this style of evaluation can only discriminate between software on a binary scale - "poor" or "neutral, potentially valuable". That is, it can discriminate between programs that are "poor", because of a faulty underlying model or poor program design or lack of documentation, and programs that are "neutral". These latter programs have a sound underlying model, are of good design and are well documented. However,the educational value of such programs is potential, not actual, and its realisation depends on factors which are extrinsic to the program. An important factor is the method of integration of the program into the learning activities of students.

There is scope to integrate computer-based activities into students' learning experiences in a variety of ways. For example, in terms of the concepts relevant to a topic of study, a computer-based activity may be used to provide an introduction to, to reinforce or to extend understanding of concepts, or to confront misconceptions. In terms of style of use, a computer-based activity may be used as a teacher-directed demonstration or as a student-directed activity to be completed in the students' own time and pace. It may be used in association with a lecture, as a component of

laboratory activities, or as an extension to traditional problem sets. If the inclusion of a computer-based activity into students' learning experiences is to warrant the added organisational effort that is necessarily entailed, then the nature of the use of a computer-based activity and its temporal relationship to other components should be decided so as to facilitate intended learning outcomes.

In this study, concept mapping was used as a device to assess the value of a computer-based activity in assisting students' conceptual understanding, and in particular, to decide how this activity should be integrated with other components of a laboratory session.

PROCEDURES

Background of students

A group of 36 students enrolled in a second-year genetics subject at a College of Advanced Education formed the sample on which the study was carried out. This sample was a subset of the total enrolment of 50 students, and comprising those students who completed all the activities. The students were familiar with the technique of concept mapping, having previously prepared a concept map on a topic of study of genetics.

Design of study

Students in the sample first attended a lecture on polygenic inheritance, and, at the end of the lecture, were asked to prepare a concept map on 'polygenic inheritance'. The students were not supplied with a list of concepts but had to generate their own. This was map #1. Several days after the lecture, the students attended a laboratory session. For this session, the students were divided into two groups. One group, termed the 'computer' or C group (N=14), first completed a computer-based activity and then engaged in data collection and analysis; the second group, termed the 'data' or D group (N=22), first collected and analysed the data, and then completed the computer-based activity. The two groups were exposed to the same learning experiences, but in a different order. The assignment of students to groups was random and was simply based on the regular laboratory groupings. The two groups were not equal in size because of absences, but it was decided to leave the groups as usual, and to test statistically for homogeneity.

On completion of each activity, the students prepared another concept map based on a modification of map #1. They were given a photocopy of map #1 and asked to modify it by adding new concepts, to correct any concepts or propositions that they now judged to be inaccurate, and to indicate with a colour highlight any concepts and propositions for which their understanding was enhanced. These modified concept maps comprised maps #2 and #3. The students were asked to indicate whether or not the activity they had completed had assisted their understanding of polygenic inheritance, and to give a brief explanation for their answer. At the end of the laboratory session, all students were asked when they thought the computer-based activity should be scheduled, and to give a brief explanation for their preference.

Analysis of Concept Maps

The concept map completed after each activity was compared with the previously completed map. The result was recorded as either map 'unchanged', if no additions or enhancements were present, or as map 'changed' if new concepts had been incorporated or existing concepts identified as better understood.

In addition, a comparison was made between the initial (#1) and the final (#3) concept maps of each student. The extent of valid changes in map #3 was used as a guide to the relative value as learning experiences, of the different order of the laboratory activities. There are several schemes for the scoring of concept maps (e.g. Novak 1985). As in that scheme, specific examples were not scored as concepts. However, in this study, the maps were not scored for heirarchical levels, and crosslinks were not differentiated from links. A concept was scored as new only if it was shown linked to a concept in the original map to generate a new proposition. A concept was scored as enhanced if it was highlighted in colour or altered by relabelling.

Description of Activities

The computer-based activity that formed one component of the laboratory session was based on program POLYGENE (Kinnear 1985), a simulation of polygeneic inheritance, which runs on an Apple IIe microcomputer. The activity was detailed in a worksheet and consisted of several investigations that were to be explored through use of the program.

The data collection and analysis involved students in measuring the heights of a sample of adult females, pooling these data with the class data, calculating the sample statistics, and developing an explanatory model based on polygenic inheritance that was consistent with the data.

RESULTS

Concept maps

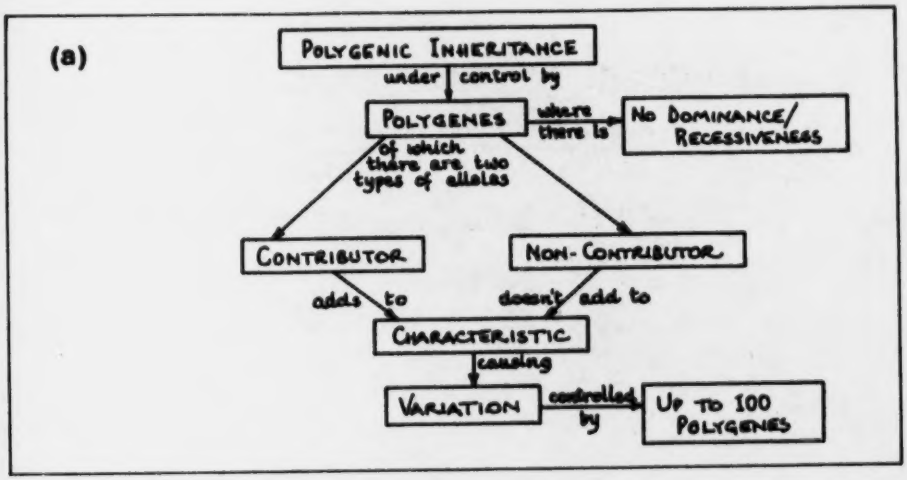
The results from the comparisons of the concept maps completed after each of the activities are shown in Table 1. It may be seen that all students in group C and the majority of students in group D modified their maps after each of the activities.

TABLE 1

Comparison of concepts maps completed after each activity

GROUP	MAP STATUS	After computer-based activity	After data collection & analysis
C	unchanged	0/14	0/14
	changed	14/14	14/14
D	unchanged	1/22	2/22
	changed	21/22	20/22

For each group, a comparison was made between the concept map (#1) prepared after the lecture and the map (#3) prepared at the end of the laboratory session. The results are shown in Table 2.



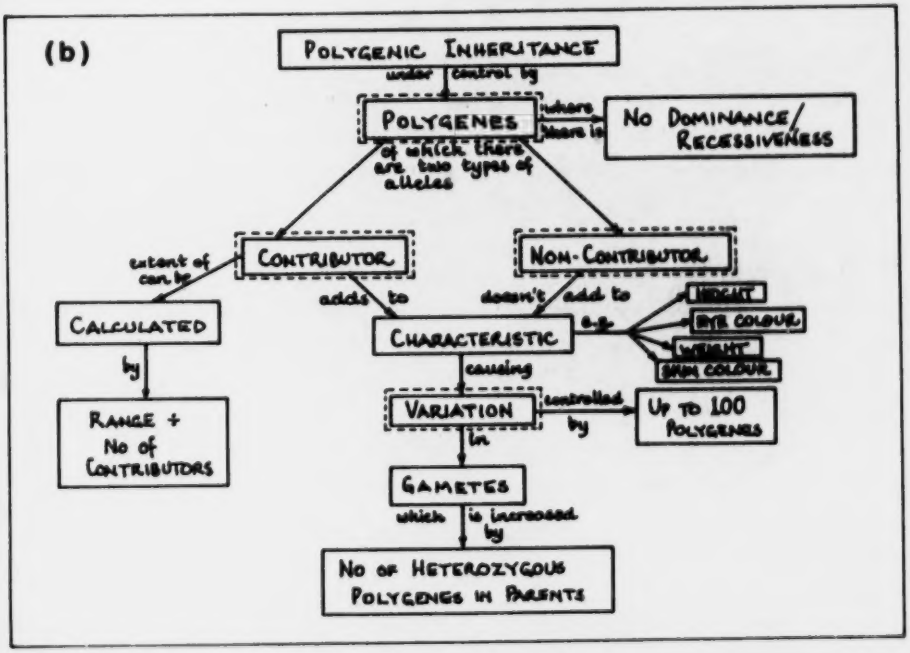


FIGURE 1 (a) Concept map completed after lecture.

(b) Concept map completed at end of laboratory class. Dotted lines denote concepts for which the student recorded enhanced understanding.

TABLE 2

Comparison of map #1 and map #3 for Groups C and D

GROUP	MEAN NUMBER OF VALID PROPOSITIONS (Map #1 : start)	MEAN NUMBER OF VALID PROPOSITIONS AND ENHANCED CONCEPTS (Map #3 : finish)
C	X = 7.4	X = 16.0
	std. dev. = 3.6	std. dev = 5.3
D	X = 7.5	X = 12.3
	std. dev. = 2.5	std. dev. = 5.1

The means for the original map (#1) of the students in groups C and D do not differ significantly, and there is no evidence for heterogeneity of variance. However, there is a difference between the groups for map #3 that is significant at the .05 level.

Responses to Questionnaire

To the question: "Did this activity assist your understanding of polygenic inheritance?", the groups responded as given in Table 3.

TABLE 3

Student perception of activity as assisting understanding

	COMPUTER-BASED ACTIVITY		DATA COLLECTION & ANALYSIS	
GROUP C	Yes	13	Yes	13
(N=14)	No	1	No	1
GROUP D	Yes	19	Yes	15
(N=22)	No	3	No	7

Responses to the question: "Which do you think is better, having the computer-based activity first or last in the laboratory session?" are shown in Table 4.

TABLE 4

Student Preference for Timing of Computer-Based Activity

	PREFER FIRST	PREFER LAST	
GROUP C	7/14	6/14	(1 no preference)
GROUP D	13/22	9/22	

DISCUSSION

Simulations should be used as a substitute for actual hands-on experiences only when those real experiences are precluded because of constraints of time, safety, space, ethical or legal factors, or cost. Polygenic inheritance warrant simulation because of the time demands of actual breeding experiments that impose constraints on student activities. Access to the POLYGENE simultation allowed the students to manipulate selected variables and observe the outcomes of experimental crosses over several generations. This type of experience has been shown to contribute to the development of students' conceptual understanding (Kinnear et al 1982).

Concept maps have been used to achieve several goals, for example, to assess the effectiveness of intervention strategies (Cleare 1983), to study student conceptual understanding (Edwards & Fraser 1983).

The results of the present study indicate that students in both groups C and D enhanced their conceptual understanding as a result of the laboratory activities. Based on the analysis of a concept maps (Table 2) and on the students own perceptions (Table 3), it appears that the students who did the computer-based activity before

undertaking the data activity made better gains in conceptual understanding from this sequence of activities than students who did the activities in the other order. It is of interest to note that there is a discrepancy in the gains in conceptual understanding as evidenced from the concept maps (Table 1) and as indicated in student responses to the questionnaire (Table 3). This suggests that analysis of concept maps may be a better indicator of gains in conceptual understanding than expression of student perception. It was apparent from comments made by some students that if, for example, they felt pressured for time, or thought that the major outcome was reinforcement, they recorded no assistance to their understanding from undertaking the activities, even though they modified their concept maps.

The students were fairly evenly divided in terms of preference for the order of the computer-based activity (Table 4). In some cases, the students' reasons were incidental to the issue of timing (e.g. "helps reinforce" or "more interesting way of learning about the same thing"). However, many students who indicated that they preferred the computer-based activity first, commented that it would provide a sound basis for understanding of the data collection and analysis activity.

In summary, concept maps were used to identify gains in conceptual understanding by students undertaking a computer-based activity as part of a laboratory session. Students gained greater benefit from this activity when it preceded, rather than followed, an activity concerned with data collection and analysis. Concept mapping, provided that it is a technique with which students are familiar, can be carried out easily and quickly in the classroom situation, and as this study indicates, can be used as an aid to decisions about integration of computer-based activities into students' learning experiences so that intended learning outcomes are facilitated. The concept maps will be of additional value in that they will be used to identify misconceptions, thus providing a guide to possible further modification of the activities.

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THE LONG-TERM KINETICS OF CONCEPTUAL DEVELOPMENT: THE CASE OF + = - AND CONTEXTUAL DIFFERENTIATION

Hanna Arzi

Kinetic studies in which changes in chemical systems are monitored over time, provide clues to reaction mechanisms. The shape of a curve representing the kinetic behaviour of a given system may change significantly along the time axis, and is characteristic of a special reaction under a specific set of conditions. Likewise studies on conceptual development over time are expected to provide clues to cognitive structure and learning processes. A survey of literature in this area shows that students' ideas prior to their exposure to school instruction on related topics have been repeatedly labelled "resistant to change" (see, for example, in Helm & Novak, 1983). The attribution of resistance is usually based on either cross-sectional studies of students' conceptions across age, or pre-post instruction studies. A major problem inherent to cross-sectional research designs is the comparability of the different age groups. The difficulty in obtaining reliable reports on the "educational history" of each age group is disturbing, since without detailed information on the presence or absence of deliberate attempts to deal with students' ideas no valid inferences can be drawn in regard to their stability. The latter problem does not exist in intervention studies. However, one should bear in mind that with such studies the usual case is a design consisting of a pretest and a relatively short intervention followed by an immediate or almost immediate posttest. Hence, conclusions rely on either the kinetic behaviour which emerges from interpolation within the time span of a study, or on speculations based on extrapolation beyond the actual follow-up. While interpolation seems to be more reliable than extrapolation, it may be rather misleading to assume that conceptual development over time proceeds along a line stretched between two measurements - a pretest and a single posttest.

Following the reservations just mentioned in regard to research on conceptual development, the present paper is concerned with the long-term kinetics of cognitive learning processes and questions whether students' preconceptions are, indeed, as stable as they are generally assumed to be. On the other hand, when a conceptual development seems to have been traced, the question is whether one can expect this to be a "true" and lasting change. Arguments related to these questions will be exemplified via findings of a study on students' learning difficulties when they are first exposed to the concept "ion." The discussion will focus on difficulties associated with the need to master the confusing terminology and symbolic representation of positively versus negatively charged particles.

LEARNING - A LONG-TERM PROCESS

The questions dealt with in this paper have been first evoked in parallel with the accumulation of data during a longitudinal study on science learning in a series of related courses taught from junior to senior high school in Israel (Arzi, 1983). The findings of this project provide empirical evidence that continuous sequences of courses are more likely to produce lasting learning, than sets of isolated teaching units. The study points to both proactive and retroactive facilitation of learning due to curriculum continuity. The existence and the long-term nature of these facilitation effects were primarily demonstrated via the case of students learning of the particulate structure of matter, and reconfirmed in the case of other physical science topics (Arzi, 1983; Arzi, Ben-Zvi, & Ganiel, in press). The results support inferences from an evaluation study in Scotland and related to similar subject matter and students at the same age range (Mitchell & Kellington, 1982). The latter project included an assessment of students' long-term retention of concepts associated with the particulate theory of matter, and the resulting low retention-ratios (i.e., delayed-post course achievement scores / immediate-post course achievement scores) were attributed to disuse of concepts following their initial learning.

The findings on retention obtained in these longitudinal classroom studies, apparently have implications for attempts to produce conceptual development. The most obvious implication is that the extent of success of an intervention might be affected by its duration. The validity of this statement can be inferred from the following example of an intervention study in which a unit on momentum and force was taught to secondary school students (Osborne & Schollum, 1981). The researchers described the posttest results as disappointing, however, they reported that classroom discussions on these results were carried out, and several weeks later significant

improvements were detected in an unannounced post-posttest. The reverse order of things was referred to in a paper on college students studying special relativity in physics: "Our interviews also indicate that what may initially appear as an accommodation may turn out to be something less than that." (Posner, Strike, Hewson, & Gertzog, 1982, p. 223).

The juxtaposition of findings on retention of science learning with findings of studies on students' existing ideas and attempts to manipulate them, led me to rethink the implicitly assumed kinetics of conceptual development. It seems that when conclusions are drawn as to whether and to what extent conceptual changes do or do not occur, the complex long-term nature of educational processes is somehow not appropriately taken into consideration. The point is illustrated in Figure 1 via a set of curves describing different hypothetical pathways of knowledge acquisition during and after instruction.

Figure 1.a represents the kinetics of an "ideal" learning process in which mastery is linearly attained within the period of instruction, and persists ever after. In "real" life, however, the amount of measured learning is not necessarily directly proportional to the amount of instruction, mastery is not the usual case and forgetting is an unavoidable process. In view of the emerging concensus for the constructivist perspective of learning, one would expect that conceptual development should not be regarded as a simple linear process in which the application of a dose of instruction implies an immediately observable increment of conceptual change. Construction of knowledge takes time and it is reasonable to expect a stage of "incubation." Hence, lag-phase kinetic models are more likely to describe the acquisitin of knowledge due to instruction (curves b-d in Figure 1). As to the kinetic behaviour after instruction, a major issue refers to the attainment of maximum learning: Does the curve reach a peak simultaneously with the completion of instruction (Figure 1.b) or sometime later (Figure 1.c & 1.d)? This question arose in 1913 when findings reported by Ballard suggested that learning can improve and reach a maximum after instruction, in contradicition with the immediate forgetting curve which had been previously established by Ebbinghaus (1885/1964). Ballard's conclusions are probably more relevant to school learning, since he studies retention of poetry which is presumably more meaningful than the nonsense syllables dealt with by Ebbinghaus. The possiblity of improved learning after instruction is supported by the longitudinal school mentioned above (Arzi, 1983). The evidence is that this is more likely to happen when some degree of curriculum continuity exists beyond the completion of a given course, rather than to result from an autonomous learning process.

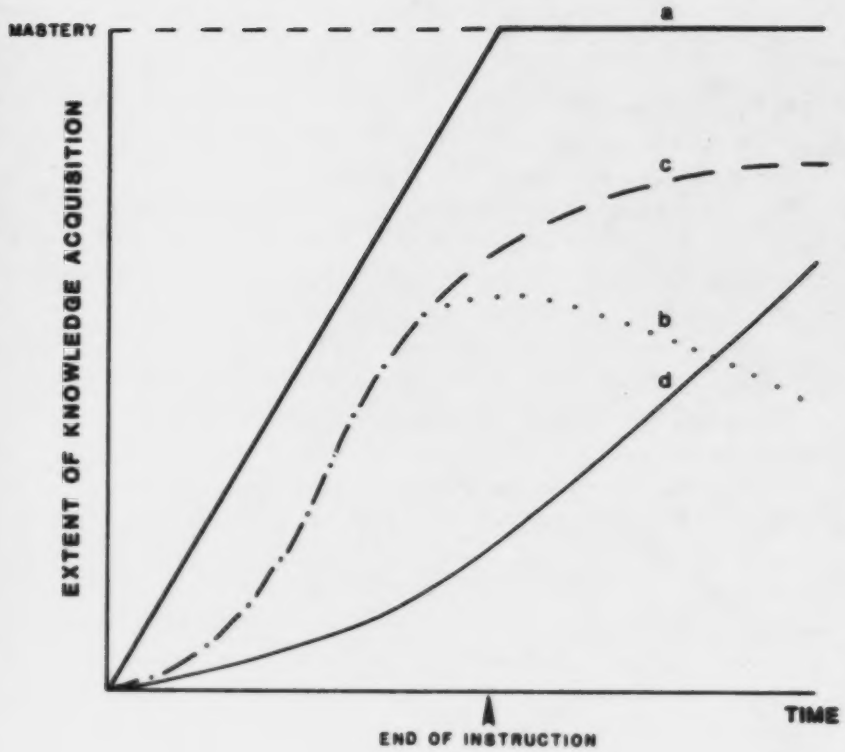

FIGURE 1. Hypothetical pathways of knowledge acquisition over time.

The following case study was part of the latter longitudinal project. Through it I shall try to exemplify and elaborate further my reservations as to the assumption of short-term and linear kinetics of oberved learning, which seems to underlie conclusions drawn from intervention studies.

IONS: A CASE STUDY OF LONG-TERM CONCEPTUAL DEVELOPMENT

The first phase of the longitudinal project was concerned with various aspects of science learning in grade 8 (age 13-14). It included an investigation into students' acquisition of knowledge and learning difficulties in a chemistry oriented physical science course. This course (Arzi, 1977) has been described elsewhere (Arzi, Sivan, & Orpas, 1980). The grade 8 study provided data showing that topics associated with the concept ions (e.g., structure of ions, ionic compounds and electrolysis) are significantly more difficult than all other topics in that course (including electric circuits, conductors and non-conductors, electric charged and the structure of the atom, elements, compounds and the Periodic Table). The relative difficulties were measured by three different instruments (achieved tests, student and teacher evaluation scales) each of which included several items for each topic. The study was replicated in two consecutive years and the same profile of relative difficulties emerged in each replication by each of the assessment methods.

Learning difficulties

There is obviously more than one reason for the difficulties students encounter when they are first exposed to ions. The following discussion focuses on a major source of difficulty which consistently emerged in the analysis of response distribution across detractors in achievement test items related to ions, and in classroom observations. This is the confusion between the different connotations of the symbols + and - in the context of mathematics versus the context of physical science. According to students' prior knowledge which has been acquired and consolidated via both school mathematics and everday life, + means "to add," and not necessarily "a net positive charge due to subtraction of electrons;" likewise, - means "to substract." and not necessarily "a net negative charge due to addition of electrons." The idea that both + and - can refer to either addition or subtraction leads to a bizarre conclusion that + = -; hence students resist accepting the physical science meaning. Thus, for example, when the symbolic representation of a negative ion was presented (Br^-, Te^{2-}, etc.) and students were asked

to point to the number of protons and electrons in that ion, the most popular incorrect operation was subtraction of and protons from the neutral atom. Subtraction of electrons was also performed, but only few added protons. When positive ions were addressed (Na^+, Fe^{3+}, etc.), the symbol + misled students to believe that addition was involved. Yet, the appropriate general rule could be parroted with relative ease: "Ions are formed by addition or subtraction of electrons; the number of protons doesn't change.

Apparently, when ions were presented, students' limited or inappropriate contextual differentiation led to faulty transfer of the mathemetical language to situations where the physical science language should be used. This was found to interfere with further learning of related topics, such as electrolysis. The extension of the problem is exemplified through students' responses on anitem which demands understanding of the microscopic level of electrolysis (item No. 17 out of 23 in a one-period mid-course test in grade 8):

A solution of cobalt bromide contains ions of cobalt, Co^{2+}, and ions of bromine, Br^-.

A solution of cobalt bromide undergoes electrolysis. Which statement is correct?

a. In the electrolysis, ions of cobalt are attracted to the positive electrode.
b. In the electrolysis, ions of bromine are attracted to the negative electrode.
c. In the electrolysis, each ion of cobalt transfers two electrons to the electrode.
d. In the electrolysis, each ion of bromine gains one electron from the electrode.
e. In the electrolysis, the cobalt ions and bromine ions become neutral.

Out of 878 students, 8% were distracted by wrong ion attractions to the electrodes (response options a & b), while as many as 27% were confused between loss and gain of electrons by negative and positive ions on positive and negative electrodes, respectively (c & d). Classroom discussions which followed the test showed that the latter confusion was also typical of some students of the 62% who successfully pointed to the correct answer (e). Presumably, these students developed test taking skills which enabled them to recognize the similarity between the appropriate response option in the case of cobalt bromide and the rotely memorized general urle "In electrolysis ions become neutral."

Contextual differentiation

In the example of ions, students' prior knowledge seems to interfere with the acquisition of new knowledge. The way grade 8 students interpret the symbols + and -

in the context of physical science exemplifies a case of PREinstructional false conceptions; but in the context of mathematics this is a case of POSTinstructional correct conceptions. Mathematics educators generally assume that mastery in the use of the symbols + and - in addition and subtraction operations which involve small positive integers is achieved by students before secondary school. Hence, these symbols and their linkages with the simple mathematical operations are probably at a steady state within the cognitive structures of 13 year old students. As such + and - are components in the system of concepts, methods of thought and other interacting factors which influence the construction of new knowledge; in other words: they are part of each individual's "intellectual ecosystem" (the latter label follows Toulmin's broad notion of "intellectual ecology" (Toulmin, 1972) and Posner's use of the term "conceptual ecology" (e.g., Posner et al., 1982). Consequently, when students are exposed to the new concepts of positive and negative ions and are faced with the respective symbolic representations, their prior knowledge as to what + and - stand for contradicts the physical science connotations they are expected to apply.

The difficulty in coping with opposing meanings of symbols is analogous to contradictions existing between meanings of words in colloquial language in "real life" and their meanings in school science. Language problems have been suggested by many as a major source for students' misconceptions in science (e.g., Gilbert, Osborne, & Fensham, 1982). However, the case of + and - is even more complex, since everyday life and school mathematics share the same meanings, and thus students also have to differentiate between two school contexts - mathematics versus science. Those students who pursue studies in senior high school disciplinary chemistry and physics, need to refine further the meanings of + and - they met in junior high integrated science. This is so since chemistry teachers and textbooks tend to refer to electric current in metallic wires as a flow of negatively charged particles from the - electrode where there is an excess of electrons to the + electrode which is electron deficient; while in physics classes students are likely to hear about positive holes moving along the potential gradient from the + to the - electrode.

Problems associated with the terminology of electrochemistry due to misleading meanings of words have already been detected by Michael Faraday in the first half of the 19th century (Williams, 1965). Faraday could not have been bothered by the + and - problems as they are referred to in this paper, since electrons and protons had not then been part of the scientific knowledge. However, he was disturbed by the use of the words "pole," "positive" and "negative," since their meanings suggested attraction and

repulsion, whilst he strongly rejected the theory (which we now accept) of attraction to the electrodes (which were termed "poles" at his time). Consequently, Faraday consulted scholars and together they coined electrochemical terms with which we are familiar today (ion, cation, anion, electrode...).

Conceptual development

A leap from a concept having a single meaning which is valid in familiar context, to the coexistence of several meanings and their appropriate applications to both familiar and unfamiliar contexts is unlikely to occur as a result of "one shot" or "transient" interventions. The mechanisms of development within students' cognitive structures probably involve the long-term processes entitled by Ausubel as progressive differentiation and integrative reconciliation (Ausubel, Novak, & Hanesian, 1978). In the case of ions, such cognitive processes may gradually lead to the consolidation and coexistence of the different meanings of + and - in different contexts.

The previously mentioned empirical evidence pointing to retroactive facilitation of lasting learning (Arzi, 1983; Arzi et al., in press), suggests that in classroom settings the effective functioning of cognitive differentiation and integration processes is likely to depend upon the continuous inclusion of the target concepts in the syllabus. Indeed, despite the fact that in the reported study students were first exposed to ions in the middle of a grade 8 course, related test achievements tended to improve towards the end of that course. This can probably be attributed to the interweaving of varied opportunities to elaborate ideas about ions, from the chapter in which ions are presented through subsequent chapters on other topics. Furthermore, despite the fact that topics associated with ions were found to be the most difficult in grade 8, the retention ratio measured at the beginning of grade 10 was not the lowest, that is, other topics which were less difficult to learn in grade 8 were retained to a lesser extent. The change in the relative extent of knowledge acquisition in different topics from an immediate to a delayed posttest, appears to be accounted for - at least partly - by the relative extent of practice of different concepts in the science program during the retention interval. In other words: Long-term exposure to concepts may compensate in some degree for initial learning difficulties as well as for forgetting.

This longitudinal data on conceptual development and the related discussion on contextual differentiation clearly agree with the perspective which prefers to focus on conceptual development more than on radical change, and to advocate for an

"evolutionary" rather than for a "revolutionary" approach in response to children's existing ideas about science (West, 1982).

CONCLUDING REMARKS ON LONG-TERM CURRICULUM, INSTRUCTION AND RESEARCH

The case study of ions (+ = -) in this paper was chosen in an attempt to bring out the importance of long-term curriculum design for effective conceptual development. Thus, a persistent use of a newly taught concept or alternative meaning for a given preconception, both within the course where the new concept or meaning has been encountered for the first time, and in subsequent courses on related topics, seems to be a necessary condition (though not sufficient) for the consolidation of desired conceptual development. Immediately observed changes following relatively short interventions, may prove to have limited scope and duration. On the other hand, when intervention continues or resumes, little initial change may eventually turn to be just an incubation stage, that is, a lag phase during which ideas ripen before they emerge. The long-term kinetic behaviour of conceptual developmenet probably reflects the type of intervention - short - or long-term, discrete or continuous - and is unlikely to be linear all the way.

The suggestion to elaborate ideas over a long time span has been mentioned sometimes as one of the points that have to be taken into consideration in teaching for conceptual development (e.g., Driver & Erickson, 1983). In view of empirical evidence and logical analysis, it seems that whatever strategy one adopts to enhance learning, it should preferably be employed over a long-term. I therefore believe that the need for long-term treatments deserves a higher priority in the agenda of science educators. Alongside long-term treatments, long-term follow-up studies are needed to expose and explore pathways of conceptual development. Investigations of changes over time will hopefully lead to more appropriate curriculum and instruction, similarly to the way in which kinetic studies of chemical changes provide clues to reaction mechanisms with consequent implications for control and application of reactions. Long-term and continuous treatments in conjunction with follow-up studies, may show that the generally assumed stability of preconceptions and the short half-life of initially perceived changes, are - to some extent - biased conclusions due to short-term and discontinuous treatments.

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CHILDREN'S IDEAS ABOUT TEMPERATURE

Ken Appleton

INTRODUCTION

A major thurst of the Learning in Science Project (Primary) at the University of Waikato, Hamilton, N.Z., has been to investigate children's ideas about a range of topics, one of which was "Hot and Cold". This paper reports on aspects of the study of that topic.

Children frequently confuse heat and temperature, and their conceptions of heat and temperature are often influenced by the volume of the object under consideration (Stavy and Berkovitz, 1980; Erickson, 1979; Driver and Russell, 1982). Driver and Russell (1982) also noted that children tend to have a poor understanding of fixed temperature points, such as freezing point.

Giving that the scope of the topic 'heat' could be quite wide it seemed preferable to concentrate the study on the more measureable quantities of heat, namely, temperature and temperature change. An interview schedule was prepared in order to explore the following ideas:

(i) the meanings of the words hot, hotter, cold, colder, temperature.

(ii) temperature changes when water volumes are changed or mixed (both qualitatively and quantitatively).

(iii) the temperature of ice in relation to the volume of ice, and to melting.

(iv) temperature measurement (using the hands and a thermometer).

(v) the processes of heating and cooling.

DATA COLLECTION

Twenty-five children (12 boys and 13 girls) were interviewed in the age range 8 to 11 years. The interviews were modelled after the interviews-about-events technique (Osborne, 1980), and used either concrete materials or pictorial representations of events to stimulate discussion on each question. All interviews were audiotaped, and were later transcribed for analysis.

This paper reports on the data obtained from those parts of the interviews pertaining to the measurement of temperature.

Each child was told that the topic for the interview was "Hot and Cold", and the child's meanings for various terms was clarified using bowls of water at different temperatures. Several qualitative aspects of temperature relating volume to temperature and temperature change were then dealt with. This led to a sequence of tasks, examples of which follow.

a) Measuring Temperatures by Hand

Each child was asked to put one hand in a bowl of cold water, and the other in a bowl of hot water, then both hands in a bucket of tap (cool) water. They were then asked: "How does the water feel to this hand? to that hand?"

Only five of the children gave the response that the water as measured by the 'cold' hand had appeared warmer than the water as measured by the 'warm' hand.

The children's difficulties may have been related to the temperature used for the bowls of water: the cold water may have been too cold, the cool water could perhaps have been warmer. For instance, one child commented that his hand was 'still numb' from the cold water.

Those who had given the expected response were asked to explain what they thought was happening. Four of the children described how their hands felt rather than how the water felt; e.g., "This hand here felt warmer cos it's been in the cold for so long, for a while, and this one felt cold because it's been in the hot". (10 year old)

An 11 year old explained it slightly differently:

"Cause my hands changed from that heat (the hot water) before going into that (bucket)."

(b) Recognition of a Thermometer

Each child was shown a mercury-in-glass thermometer, and was asked what it was. Children who were uncertain were told its name. Each child was also asked what the thermometer does (tells us). Again, those who were uncertain or did not know, were told: "It tells us how hot or cold something is".

Three children did not recognise it as a thermometer and did not know what it did. The others compared it to clinical thermometers or swimming pool thermometers. Twenty children said it told how hot or cold something was, or said that it told us the temperature of something. These children explained temperature as "how hot or cold some water is". All the children who had difficulties were 8 or 9 years old.

(c) Awareness of Typical Temperatures in Degrees

At this stage each child examined the -10^{o} to 110^{o}C thermometer, and read the air temperature. Help was provided if necessary to assist the child to identify the scale and the mercury column which indicated the temperature reading. Each child was then asked "What number would the thermometer go to if we put it in:

some water we have just boiled to make a cup of tea?

a cold drink with lots of ice in it?"

The temperatures the children suggested were almost qualified by terms like 'about' or 'probably', and a temperature. This seems to indicate that the children were uncertain about the temperature, and some may have been guessing just to satisfy the interviewer's request for a number. This was confirmed for five children (e.g. some who said boiled water would be around $10-30^{o}$C) who admitted to guessing, when their answer was probed further.

One child gave no temperature for the iced water because "(the thermometer's) used for measuring heat".

(d) Thermometer Operation

When asked how they thought the thermometer worked, nine children said they did not know, but thirteen attempted some explanation. Eight of these suggested that the thermometer was sensitive to heat, or 'made to' go to the right number.

"There's something that makes it go. Maybe there's something in the silver bit here that when you put it in a container it goes up to a number". (8 yr old)

"It's sensitive to hot and cold water". (10 yr old)

Two children explained it by the idea of pressure, or pushing:
"When it gets hot the ... it start to squeeze out. The pressure's hot ...". (10 yr old)

Three children mentioned that heat rises:
"...heat rises and um that could be so like that (the mercury) rises with it. And um cold goes down lower. Cold might go down lower and that's why it (the mercury) goes down." (10 yr old)
"...when the mercury gets hot it rises". (11 yr old)

However, the children did not show great commitment to their ideas: they generally were speculative and added qualificatory words such as 'probably', 'perhaps' and 'maybe'.

DISCUSSION

(a) Apparently simple and straightforward activities on temperature with this group of children were found to expose a high level of ignorance regarding relatively basic ideas about temperature and its measurement

This is best exemplified by the children's general ignorance of temperatures for boiled water and iced water in task (c). Eleven children gave a response in the $0^{o} - 10^{o}$ range for iced water, and only six suggested a temperature in the $90^{o} - 100^{o}$ range for boiled water.

Even the apparently simple activity in task (a) (trying hands in water of different temperature) revealed problems for the children. It was originally included in the interview to explore the idea that the hands are unreliable in gauging temperature, and as such appeared to be a fairly simple activity. However, the outcome for 58% of the children was different from the expected outcome, yet this diffidulty does not seem to have emerged in classroom teaching of the activity. For example, the book from which the activity was originally taken was trialled by teachers.

(b) The children's subjective knowlege may influence what they actually 'observe'

This appeared to happen when some children did task (a) (trying hands in water of

different temperature). Why did children give inappropriate responses to such an apparently simple activity? A possible explanation is that the children said what their common sense or intuitive knowlege told them should happen. The actual sensations experienced were neither not noticed or ignored. For example,

> Simple reasoning would suggest that a hand which has just been in cold water is going to remain cold for a while, even if it is put in some other water; similarly for a hand which has been in hot water. Therefore the children observed that the 'cold' hand still felt cold, and the 'hot' hand still felt hot. Alternatively, common sense would suggest that if both hands are put into the same bucket of water, then both hands must feel the same sensation. Hence some children 'observed' that the water felt the same.

These findings support those of other researchers such as Driver and Russell (1982), and reveal major difficulties children have in measuring and quantifying temperatures. If teachers are unaware of the extent of the children's difficulties, then there is a need for teacher material based upon these and other findings.

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CHILDREN'S UNDERSTANDING OF ELECTRIC CURRENT IN THREE COUNTRIES

William Butts

There have been many investigations of children's understanding of electric current in the last ten years (e.g. Andersson and Karrquist, 1979: Russell, 1980; Osborne, 1981; Shipstone, 1982). Many of these studies have focussed on simple "battery and bulb" circuits. In this situation, Osborne (1981, 1983) has proposed that children operate with one of four models:

1. the scientist's "equal current model" in which the current is considered to be the same both before entering and after leaving the bulb;

2. a "diminished current model", in which current is believed to travel around the circuit but to be "used up" partially, in producing light in the bulb;

3. a "clashing currents model", in which it is the clashing of currents coming from each pole of the battery that is thought to create the light in the bulb and;

4. an "extinction model", in which the current coming from the battery is believed to be used up in the production of light at the bulb, even though a "return wire" may be deemed necessary.

PURPOSE OF THIS STUDY

To illustrate the technique of "interviews about instances" (IAI) to pre-service science teachers, interviews were conducted with school children in the age range 12-15 years using a simplification of the original "electric current IAI" of Osborne & Gilbert (1979). The interviews were videotaped. The children interviewed were from three countries, England (Leeds), New Zealand (Hamilton) and Australia (Sydney). Only a very

small sample was selected in each location, the criterion for selection being that the children were considered by their science teacher to have enough confidence to speak freely while being interviewed on camera. The interviews lasted from 10 to 12 minutes; because of the purpose of the project they were much shorter than typical "interviews about instances" conducted for research purposes.

TABLE 1

MODEL OF ELECTRIC CURRENT USED BY 16 CHILDREN IN 3 COUNTRIES

MODEL	LEEDS		HAMILTON		SYDNEY	
	NAME	AGE	NAME	AGE	NAME	AGE
Scientist's Model	Zoe Cathy	13 15	Rachael Cecilia	12 15		
Diminished Current Model	Michael	14	Joanne John	15 15	Samantha Brett	14 15*
Clashing Currents Model	Miranda Jason	13 15	Simon Sheridyn	13 14	Craig	14
Extinction Model	John	13			Cathy	15**

* Switched from a "clashing" to "diminished" model during interview.

** Switched from an "extinction" to a "diminished" model during interview.

RESULTS

In spite of the small sample, only 16 children in total, evidence was produced for the existence of three of the four models proposed by Osborne, in each of the three countries involved. All four models have adherents among the six children from Leeds. None of the six Hamilton children used the "extinction model" and, of the four

Sydney children interviewed, none operated with the "scientist's model". It should be noted that all the children had studied electric current, including battery and bulb circuits, formally in school science classes.

A videotape, consisting of edited excerpts of the recorded interviews, has been assembled to illustrate the similarity in understanding across the samples from three countries. It shows children's responses to the two IAI cards containing (i) a battery and single bulb (which reveals the model used by the child) and (ii) a battery and two similar bulbs in series (which enables the application of the model to another situation to be explored). Table 1 indicates the model adopted by each of the 16 children interviewed. Generally the models were consistently applied throughout the discussion of the eight instances depicted on the IAI cards, although two children switched models during the interview.

CONCLUSION

This project was not conceived as a research study and clearly it would be dangerous to generalize from the small and atypical sample of children involved. Nor were the interviews as extended and probing as would be expected in a research study. Nevertheless it is of interest that, even in such a small sample, three of the models of electric current which Osborne has proposed have been identified in each country. The results may be taken as further evidence, however, weak, of the universality of children's conceptions of the world.

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Research in Science Education, 1985, 15.

LEARNERS' RESPONSE TO THE IDEA OF ENVIRONMENT

Peter Fensham and Barbara Johnson

Schaeffer (1979) has used word association in a number of studies including a number of collaborative cross-cultural ones. Most of these have involved associations with biological words. These data have been an important source of his three-fold view of concepts, the Burr Model, as components of a learner's cognitive structure that have "personal meaning" and hence may affect every day behaviour.

Schaeffer's work, and that of his collaborators like Hernandez (1983) have indicated that associations are relatively easy to collect from school students from 9 years of age and older. There also seems to be evidence that quite stable patterns of responses are obtained when associations are gathered from groups of students in a given socio-cultural setting.

Australian environmental educators have been very active for more than a decade in promoting environmental education in schools and in the wider community. Most of the educational energy in the environmental movement has gone into curriculum development and promotion and there are very few research studies.

The technique of word association and the findings reported above encouraged us to begin to fill this gap in Australian educational research.

The present study is intended to provide more information on the use of word associations with Australian students across a wide age range and to see whether evidence can be obtained that social factors are linked to changes in the patterns of associations.

Two social factors were chosen for this exploration of how different social milieux may influence the meaning of the concept, Environment.

The first is the different interactions with the same social milieux that people have as a result of growing older. The second is the impact of an explicit presence in a school's curriculum of environmental studies.

DESIGN

The respondents were drawn from three primary schools and two secondary schools in adjoining suburbs of outer-eastern Melbourne. The primary schools were feeder schools to these two neighbouring high schools, one of which has been noted for some years for its environmental education. The "environmental" high school includes in its Year 8 curriculum a compulsory subject, Environmental Studies, and there are permanent reminders of this in the school grounds in the form of different natural eco-systems.

One of the primary schools also, by chance, had one Grade 5 in our sample with a teacher who had included earlier in the year explicit environmental emphases in her teaching.

It is postulated in this design that the interactions of these students of different ages with the social sources of environmental knowledge that exist in their common geographical locality will be significantly different, and that the explicit school learning in environmental education for some of the students in the study could be another significant social factor.

DATA COLLECTION

Trials in two other secondary schools and in one other primary school established an effective procedure for collecting word associations.

Each student was given a sheet of paper containing the key-word (ENVIRONMENT, etc.) repeated in a column with a space indicated alongside each indicating where the associations were to be written. The administrator then gave an instruction for the students to write in the spaces any words that came into their mind when they thought about the key-word. They were encouraged to write anything they thought of and not to be concerned with ideas of right or wrong answers. After about two minutes most students at all ages had completed writing the associations that came easily to mind. The task was then repeated with a new response sheet for each of the other key words. The order of presentation was GREENIE, POLLUTION, CONSERVATION, ENVIRONMENT. Since the earlier tasks may influence the later ones, there is a need to explore the effect of this sort of cueing.

In the case of the classes in Years 7 and 9, the data were collected by one of us during what would have been a science lesson, and in the case of the Year 11s during an English lesson, since this was their only common subject.

THE DATA FROM THE STUDY

The responses for each key word were listed. Words with apparently similar meaning were classified into about 20 categories initially, and then a second run enabled these to be collapsed into 11 categories for each key word. The broad titles of these are given in Table 1 and it will be seen that a number recur for several of the key words.

CATEGORY OF RESPONSE	GREENIE	POLLUTION	CONSERVATION	ENVIRONMENT
A	Health	Living things	Living things	Living things
B	Human products	Chemical	Nature	Nature
C	Values	Waste	Water	Water
D	People	Health	Land	Natural environment
E	Living	Values	People	Atmosphere
F	Nature	Water	Preserving	Health
G	Conservation	Atmosphere	Protection	Values
H	Protect	City	Values	People
I	Symbols	People	Energy	Built environment
J	Mucous	Unrelated	Built environment	Surrounding space

Table 1 : Broad titles of categories into which the word associations were classified for each of the four key words.

The data for each year level and type of school can be reported in a number of ways. In this paper they are presented in terms of the percentage of students in each responding group giving at least one association in a category. This emphasises the variety of sorts of associations the members of a group are making. It does not report the number of associations in a given category, i.e., the intensity of a response category, students may make.

FINDINGS

Figure 1 presents histograms of the percentage of students in Year 9 in the two schools responding with an association to ENVIRONMENT that was in categories A-J of Table 1.

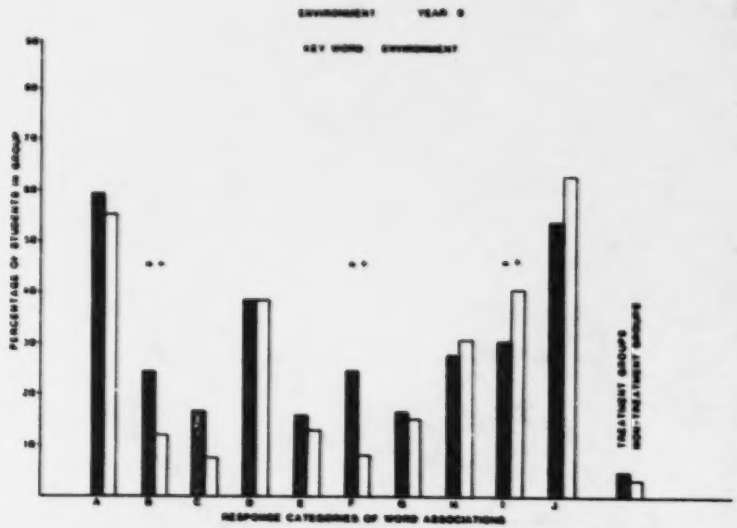

Figure 1 : Percentages of students in Year 9 responding in the categories of word associations to Environment. (* indicates 10 or more percentile points of difference (±) between "treatment" and non-treatment groups).

These data and the corresponding response percentages from the two groups ("treatment" school and "non-treatment" school) in Years 5, 7, 9 and 11 are given for each category (A-J, ENVIRONMENT) in Figure 2.

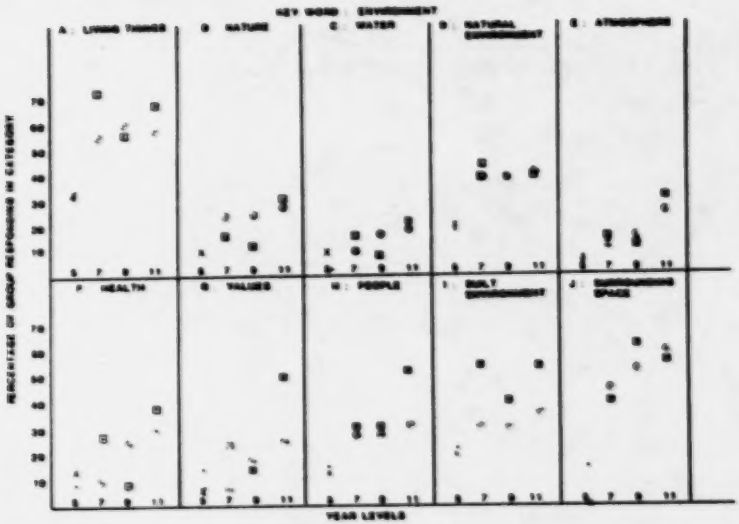

Figure 2: Percentages of students in the "treatment" and non-treatment groups at Year levels 5, 7, 9 and 11 responding in each category of word associations to Environment.

Similar diagrams could of course be presented for the response categories to the other key words.

It will be evident that there are differences and similarities in the two sets of responses in Figure 1. For the purpose of the discussion in this paper, two responses to a category of association are deemed to be "different" if they differ by 10 or more percentile. Such differences in responses are indicated by an * in the figures and by a + or - for differences when the treatment school's responses are higher or lower than those in the non-treatment school. Pairs of responses for which the difference is more

than 20 percentile are indicated by **. It may well be reasonable to assume that these larger response differences, given their rarity (12 out of 180 comparisons) are indicative of some sort of school effect in which formal teaching or some other school-based events within the memory of the reporting group are responsible. The occurrence of four of these in the Year 5 comparisons in categories known to be consistent with emphases in the environmental treatment of the teacher supports this assumption.

Comparisons related to the Overt Environment Curriculum

In Table 2 the differences in the paired responses for the year level groups in the two sorts of schools are reported.

KEY WORDS	NUMBER OF RESPONSE CATEGORIES PRIMARY : YEAR 5 COMPARISON		
	T > N-T	T < N-T	T= N-T
GREENIE	2	1	7
POLLUTION	4	2	4
CONSERVATION	4	0	6
ENVIRONMENT	0	1	9

SECONDARY : YEARS 7, 9, 11 COMPARISONS

	T > N-T			T < N-T			T = N-T		
	7	9	11	7	9	11	7	9	11
GREENIE	1	1	1	2	1	3	7	8	6
POLLUTION	1	0	3	3	4	1	6	6	6
CONSERVATION	3	0	3	0	7	0	7	3	7
ENVIRONMENT	0	2	0	4	1	4	6	7	6

Table 2 : The differences in the responses to the key words between the year level groups in the "treatment" (T) and "non-treatment" (N-T) schools.

More than 60% of the 40 categories compared for each level of schooling show no difference. In the case of the two Year 5 groups, there are 10 differences in favour of the treatment group compared with 4 for the non-treatment group. As indicated above, these differences do seem to reflect a treatment effect from what is known of the treatment's emphases.

In the comparison of the secondary schools, there is no obvious evidence of an effect of the treatment in Year 8. Indeed the non-treatment group outscore the treatment group in a number of categories for CONSERVATION and POLLUTION. The environmental treatment in Year 8 was ecological in emphasis rather than problem oriented. It is not surprising that it did not lead to an increase of associations to these key words and one can only speculate (with some support in the data) whether its emphasis on natural ecology may have obscured the students' awareness of the meaning of the more problematic key-words.

Comparisons related to Age Interactions

To explore evidence for an effect of the age of students, a comparison (see Table 3) was made of the mean responses in the 40 categories of the Year 7 students as a combined group and of the Year 11 students. A comparison of Year 11 and Year 5 seemed less appropriate because the Year 5 were so much less fluent at the association task and because of the special treatment one group of them had had.

KEY WORD	NUMBER OF RESPONSE CATEGORIES Years 11-7 > 10 percentile
GREENIE	7
POLLUTION	5
CONSERVATION	6
ENVIRONMENT	6
TOTAL	24

Table 3: The number of categories of word associations for each key word for which the Year 11 group differed from the Year 7 group by 10 or more percentile.

Twenty four of the categories show a positive difference in favour of the Year 11s and for the remaining 16 there is no difference. Among those showing a difference are 5 categories that obviously relate to an awareness of the problematic aspects of these key words, a trend consistent with the sorts of wider contacts with the social milieux that age could easily provide.

Thus living longer (from 12 years of age to 16) does seem to widen the students' range of associations with these key environmental words. This conclusion does, however, need to be tempered by the fact that some of the age group has left school before the Year 11 testing, and those who remain may be responsive to these ideas.

CONCLUSION

This study confirms with Victorian School students two assertions about the word association technique in a number of other countries. These sorts of associations are relatively easily collected from school students at different levels, although Year 5 may be the lower limit for reasonable data. There is also a considerable and rather surprising constancy in the patterns of responses when relatively simply-applied categories are developed from the data. A great part of the pattern of responses is stable for each year level, although there is a substantial shift in the patterns with age (Year 7 to Year 11). The changing interaction of age with the same social milieu does seem to affect associations more than the curricular differences at work in these secondary schools.

Curricular treatment effects do seem to be revealed since the patterns of the treatment group at Year 5 did show a number of differences from their "untreated" peers, and at Year 9 there were very few significant differences. This is consistent with the known nature of these two treatments of environmental education. The methodology is thus one that can readily reveal the presence or absence of some intended learnings.

The constancy of the patterns, given the varieties of learning situations of the pairs of groups here at four levels of schooling, suggests that the responses to the word-association task are largely determined by extra-school influences. Conversely the method seems to be a useful one to probe quickly these sorts of general awareness that students bring to school.

Finally, there is no evidence of the negative/positive patterns that Schaeffer suggested for West Germany and Philippine students respectively.

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CIRCULAR MOTION CONCEPTS OF FIRST YEAR ENGINEERING STUDENTS

Peter Searle

INTRODUCTION

This paper reports the views of first year engineering students on a number of aspects of circular motion. The concepts of circular motion are difficult for many students of introductory physics to understand. Finley et al (1982) in a questionnaire study of 68 high school physics teachers found that circular motion was regarded as the most difficult concept for students. Interestingly, in the same survey circular motion did not appear in the top 15 of the topics regarded as the most important. There are undoubtedly a number of reasons contributing to student difficulty, one of which is their intuitive ideas or misconceptions in the topic.

Clement (1982), McCloskey (1983) and Viennot (1979) found misconceptions in circular motion as part of their more general analyses of conceptual understanding in mechanics among tertiary students. More recently Gunstone (1984) and Gardner (1984) investigated the alternative frameworks of year 10 and year 12 students in circular motion. The study reported in this paper builds on the work mentioned above and extends it into a specific analysis of circular concepts of tertiary students.

THE INSTRUMENT AND SAMPLE

The test contains seven questions (most with sub-parts) of the DOE type (Demonstrate, Observe, Explain) developed by Champagne, Klopfer & Anderson (1979). The aim of the questions is to present a practical situation involving some aspect of physics which students have to predict and explain. After the experiment is observed by students they then must compare their prediction with the actual experimental outcome. Appendix I gives an outline of each question. Two questions (3 & 5) are shown in full in Appendix II. The test was designed to investigate the well-known

misconceptions in classical mechanics : motion implies force belief, and the impetus perspective. In addition, the instrument was to explore the commonly held view (Gardner, 1981) that an outward (or centrifugal) force acts on objects moving in a circle. Two pieces of apparatus were used to investigate the acceleration concepts, a laboratory cart which could be accelerated along the floor, and a rotation table. Each had a small frame to which a small mass was attached by a length of fine cotton. The idea for the apparatus came from a videotape on circular motion. The instructional strategy used in the film was to show that the position taken by the accelerating mass was the same in both linear and circular cases and hence the acceleration of the rotating mass must be toward the centre. The strategy therefore depends on students' understanding Newton's Second Law and transferring that knowledge to the circular example. It was hoped that the test would indicate if such a strategy could be successful.

The sample consisted of 19 male first-year engineering students at the Bendigo College of Advanced Education. Student ages ranged from 18 to 30 years with the average being 21 years. (Four students were aged 25 years or more). All students were taking the subject Engineering Physics, which contains a small section covering the topics gravitation and circular motion. The test was administered some five months after the topics had been covered in class. Any short-term benefits from classroom instruction can be assumed to have dissipated, leaving only long-term understanding (or misunderstanding) of the topic for analysis.

RESULTS

Displacement implies a force

The overwhelming conclusion to be drawn from an analysis of the linear acceleration and radial acceleration experiments is that most of the students believe a force must be acting in the same direction as the displacement of the mass. In the linear case 84% of students predicted the correct position of the mass but only 16% could correctly mark the forces acting. None of the 19 respondents predicted the correct net force. For the circular motion experiment, the correct responses were 89%, 11% and 5% respectively.

The acceleration of the glider seems to have been irrelevant to the majority of students who have taken the glider as their frame of reference. The most common

error (Table 1) incorporates a force F acting to the right (the glider is accelerating to the left). The force is explained under many guises:

"... horizontal force F due to the inertia of the mass";
"F created by the momentum force";
"... the mass will try and resist this movement".

Explanations for the outward force in the circular motion case include:

"... a force due to centripetal motion ... will pull ball outwards";
"There is a force throwing the particle outward".

In many cases the outward force is not explained or labelled - it is simply a force that is needed to explain the deflection of the mass. Gardner (1984) found similar responses among Year 12 students.

TABLE 1

		POS.		FORCES				NET FORCE				EXP.	
		Cor	Inc	Cor	Inc	Oth	Most Comm. error	Cor	Inc	Oth	Most Comm. error	Sat	Unsat
Q3	n	16	3	3	15	1	12	0	17	2	6	0	19
	%	84	16	16	79	5	63	0	89	11	32	0	100
Q4	n	17	2	2	16	1	10	1	17	1	6	1	18
Q5	%	89	11	11	84	5	53	5	89	6	32	5	95

Equilibrium framework

A small number of students (three in Q.3 and two in Q.5) indicated that the net force acting on the mass is zero. At first glance this appears a surprising result since the majority of students appear to see the mass as "at rest" relative to the glider. However, after consideration of the next section (The resultant force concept) the number of students who regard the problem as an equilibrium one could be as high as nine.

It is surprising that friction was not used by more students in their explanation for Q.3. It would appear the "logical" choice to explain the position of the mass. Even for the 7 students who invoked friction for their explanation of Q.2, only three continued with it in Q.3.

TABLE 2

		Path Prediction		*Explanation*		*Most Common Error*
		Cor	*Inc*	*Sat*	*Unsat*	
Q6	*n*	*10*	*9*	*6*	*13*	*5*
	%	*53*	*47*	*32*	*68*	*26*
		Com Movement		*Explanation*		*Most Common Error*
		Cor	*Inc*	*Sat*	*Unsat*	
Q7	*n*	*15*	*4*	*1*	*18*	*3*
	%	*79*	*21*	*5*	*95*	*16*
						Both coins slip at same speed

The resultant force misconception

When asked to find the resultant force acting on the mass under acceleration the most common mistake was to add vectorially the "outward force F" and the weight (Table 1). The tension force is ignored in the calculation of resultant force. The 'resultant force' is often drawn as being opposite in direction to the tension force with the implication that the "resultant resultant force" is zero. That is, the student perceives the mass as being in equilibrium. The concept of the resultant force as being the sum of all forces appears to be weakly held by students. In addition, the fundamental principle of resultant force being in the direction of accelertion is not widely appreciated. In fact one student (No. 16) stated "...net force is in the opposite direction to the acceleration".

Motion implies force view

In question 5 (forces acting during circular motion), only one student included a force in the direction of the tangential velocity. It was referred to as a "tangential force". For this example of circular motion it seems that the majority of students do not need to invoke the "motion implies force" concept to explain the path taken.

The motion implies force view was more evident in explanations of the constant velocity experiment (Q.2). For example :

Student No. 5: "F_x is the force due to motion. F_a the air resistance. F_a is smaller than F_x and there is a net force of F_x-F_a"

Student No. 6: "If the glider was to move with linear velocity and motion as it was described to do, then the system must have a nett force relationship".

Impetus perspective

In question 6, ten students predicted a tangential path when the ball was released from the rotating table. Of these, six provided a "satisfactory" explanation of the experiment. However, it is interesting to note that four explanations were statements only, without any physical justification. For example, student No. 2 stated that : "The ball will travel directly from its release position in a tangential direction from the turntable." The most common misconception was for students to predict a direction at an angle from the tangent to the circle (Table 2). The justification for this path appears to be a vector addition of the "forward" (tangential) and "outward" forces acting on the mass. That is, some students believe that if there is forward movement,

then there must be a forward force associated with it - the impetus concept. For example, student No. 16 predicts the path will "... continue in a straight line but there will be a small force acting outwards. At high speed the force will be greater...".

The intuitive science/formal science amalgam

A number of students exhibited a range of formal science and intuitive science concepts in answering a range of questions. This is not surprising, since a number of studies (Viennot, 1979; Gunstone & White, 1981 (b)) have shown the resistance of misconceptions to change or removal. These misconceptions will often be overlaid with the more weakly held school science learning. Some examples of the confused response which can result from such an amalgam of concepts are:

Student No. 6, Q.6: "The ball will experience a centripetal force which acts in towards the centre of the table. There is also a velocity acting tangential. The resultant of this will project the ball out at an angle from the direction of motion a certain angle and distance. Both is dependent upon the radial velocity".

This student has learnt of an inward centripetal force and a tangential velocity but still appears to want the mass to move away at an angle to the tangent. Furthermore, there is poor differentation of terms as velocity and force are considered as quantities which can be added.

Student No. 1, Q.5: "Since the mass is changing direction constantly, there is an acceleration towards the centre of the wheel. A force ma throws the mass out from the wheel, that the force mg are balance by the tension T. The net force F is due to the acceleration causing the change in direction".

Here again the student is aware of both centripetal acceleration and a net force toward the centre of rotation. In addition however, he feels the need for an outward force (ma) as well, as necessary for his intuitive belief in equilibrium.

CONCLUSIONS AND IMPLICATIONS

The results reported above indicate widespread misconceptions regarding circular motion. The principles of Newtonian physics are not well understood and most responses indicate a combination of taught Newtonian concepts and intuitive ideas

about motion. The majority of students were able to predict the correct position of the mass in each task. That is, intuitively, most students could predict the position of the mass. However, attempts to explain the position using force diagrams and written explanation were manifestly unsuccessful. Gunstone and White (1981)(a), in a study of physics students at Monash University also found many of them unable to explain their predictions adequately.

In devising instructional strategies, science educators must place more emphasis on the qualitative aspects of physics, and encourage more discussion in the analysis of problems. It is well known that passing physics exams does not mean students have a good conceptual understanding of the subject (e.g. Lin (1982). In talking about problems in physics (as distinct from plugging numbers into formulae) students may become more aware of their own learning processes as well as overcoming their misconceptions. There has been some work already attempted in this area with student teachers (Northfield and Gunstone, 1983).

Furthermore, the skills involved in drawing and understanding force diagrams need to be developed further. In particular a clear distinction must be made between the forces acting on an object and the net force. For example, a number of students labelled the outward force acting on the accelerating mass as ma or mv^2/r, which was subsequently treated as just another of the forces acting on the object. Student comprehension of the implications of F = ma does not appear to be good. The acceleration of the cart (and mass) was not a primary concept to be considered by many students.

The term "centrifugal" was used by only one student in relation to Q.6 (path taken by projectile). However, "centripetal" was commonly used to mean "from the centre". The instructional problem therefore may not be to distinguish between 'centripetal' and 'centrifugal' or avoid 'centrifugal' completely - but to define, explain and reinforce the meaning of 'centripetal'.

In considering the effectiveness of the film on circular motion (Note 1) there appear to be a number of difficulties. Firstly, the students who took part in this study do not have a firm understanding of basic Newtonian mechanics. An understanding of the linear acceleration example may be sketchy at best. Secondly, assuming transfer does occur from the linear to the circular motion case, misconceptions will be transferred also, so compounding the problem further. For the film to be successful

both pre- and post-film discussion of a number of everyday circular motion situations would be necessary. Science educators, through constant familiarity, often take the principles of Newtonian mechanics to be self-evident and obvious to all. We should remember that even Newton was non-Newtonian for many years and "commenced the Principa in 1684 with a dynamics built on a concept of impetus" (Uritam, 1974). There is a good case to be made for the teaching of some pre-Newtonian mechanics to highlight the difficulties in using such ideas, and then emphasizing the power and simplicity of Newtonian mechanics. Such a strategy may enable students to understand their own misconceptions when considered within the historical development of mechanics. Finally, there is some cause for optimism. Student No. 5 in explaining his prediction for Q.7 provided the near-perfect answer.

"The radius of Y is larger than X, the centripetal force on Y therefore is larger than X. As the speed increases such that it exceeds the frictional force Y will fly off first".

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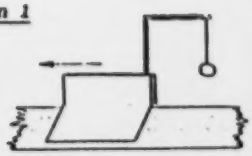
APPENDIX I

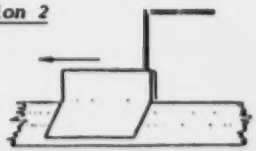
A SUMMARY OF THE CONTENTS OF THE TEST

Question 1



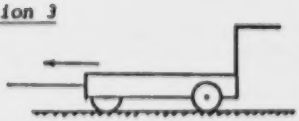
Air track glider at rest.
Indicate all forces acting on the mass.
Explain the choice of forces.

Question 2



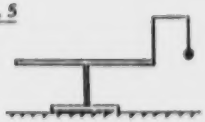
Glider moving at constant velocity.
Predict position of mass at high and low velocity.
Draw forces acting on mass at low velocity.
Indicate net force and give reasons.
Compare observation and predictions.

Question 3



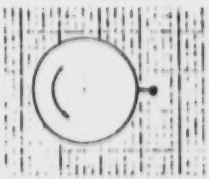
Cart moving at constant acceleration.
Draw position of mass, show all forces acting and indicate the net force acting on the mass.
Explain choice of forces and net force. Compare observation and prediction.

Question 4,5



Circular motion, constant speed.
Predict position of mass at high and low speeds.
Forces, net force and comparison as for question 3.

Question 6



Circular motion, constant speed.
Predict path taken when mass is released.
Low and high speed. Explanation.
Comparison of prediction and observation.

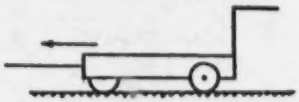
Question 7

Two coins placed on rotation table.
Spoed of table increases. Which will slip first? Explain choice. Comparison of observation and prediction.

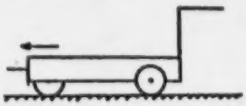
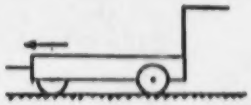
APPENDIX II

Question 3 and 5 of the test. (The size of diagrams and space allocated for responses has been reduced).

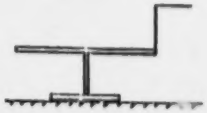
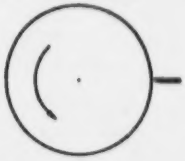
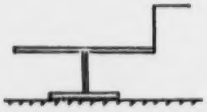
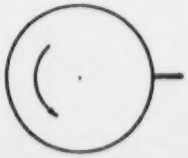
Q.3 The diagram below represents a cart moving across the floor with a constant acceleration. i.e. the velocity changes by the same amount each second. (Again the position of the mass is not shown).



Draw the position of the mass and string on the diagram provided (Diagram A). On the same diagram show all the forces acting on the mass. On diagram B indicate the net force acting on the mass. Again briefly explain your choice of position, forces acting, and net force.

A. Position and forces acting	B. Net force
	
C. Explanation	
D. Comparison of Observation and Prediction	

Q.5 For the turntable spinning at low constant speed use the diagrams to show all the forces acting as well as the net force. Give brief reasons for your predictions. (Either or both diagrams can be used to illustrate the forces).

A. Forces acting	B.
	
C. Net force	D.
	
E. Explanation	
F. Comparison of Observation and Prediction	

Research in Science Education, 1985, 15.

TEACHERS' CONCEPTS IN SCIENCE

Catherine Ameh and Richard Gunstone

INTRODUCTION

This paper presents the results of the adminsitering of a pencil and paper test of aspects of science concepts to trainee secondary school science teachers. The test has been developed for use in a larger study of Nigerian science teachers and their students.

The Instrument:

The test is based on the questions which are the Interview About Instances and Interview About Events techniques (Osborne, 1980). The questions used cover nine concepts: animal (questions taken from Osborne, 1982), plant, living (questions of identical form to those for animal), force (see Osborn, 1982), friction (see Stead and Osborne, 1981), electric current (see Working Paper No. 25 - Electric Current, Learning in Science Project), gravity (see Working Paper No. 20 - Gravity, Learning in Science Project), light (see Stead and Osborne, 1980), and chemical reaction (see Working Paper No. 27 - Chemical Change, Learning in Science Project).

The Sample:

The sample comprised science graduates undertaking a one year secondary teacher training course at Monash University in 1985. All respondents were enrolled in a Methods Course for junior secondary school science teaching. The 42 respondents represent about 80% of this group. All respondents had major science studies in either Biology or Chemistry. No physics students were in the group, as none were enrolled in this course.

The test was administered in the fourth week of the course and most completed the test in 50 - 60 minutes.

RESULTS

Results for some of the concepts are presented below. For the first of these ("animal") a more extensive listing and discussion of results occur, while less detail is given for the remaining concepts.

Concept of Animal:

In this section, there are 16 questions: 12 are instances of animals (in order - frog, snail, rabbit, bat, cow, worm, fish, boy and girl, fly, grasshopper, bird and lizard); 4 are non-instances (in order - car, lettuce, fire, glass). There are two parts to each question: a) requires the respondents to tick the appropriate answer (Yes or No); b) requires the respondents to give reasons for the choice. In this study, appropriate attributes to appear in the reasons would include: heterotrophic feeding, movement, digestive system, nervous system and cellular structure (cellular structure in terms of cell membrane). Respondents who were consistent in the above attributes, as well as in classifying the instances, were considered to have a scientific view of animals. On these criteria, only 26% were considered to have a scientific view of animals. A further 57% gave reasonable reasons which might be accepted as biological characteristics of animals, but did not distinguish "animals" from any other living things. Some of these characteristics were: complex structure, reproduction, respiration, lack of chlorophyll, lack of photosynthesis, DNA/RNA, excretion, circulatory system, response to stimuli and growth.

The remaining 17% were considered scientifically inadequate because the listed attributes were confined to a specific group of animals, e.g. warm blooded, backbone, phylum chordata, live on land.

Unscientific statements about animals:

.Respondent 5 - "it is a chordate, its skeleton is internal, it has a blood system and can move". While this reason may be true of a particular animal, it does not distinguish the animal kingdom, e.g., all animals are not chordates, not all animals have an internal skeleton.

.Respondent 9 - "Animals are living things that are not plants". This is not a sufficient reason for this purpose.

.Respondent 21 - "It's an animal because 'no chlorophyll, no cell walls (only cell membrane), no vacuole'". Animals don't have chlorophyll, but there are also plants that don't have chlorophyll. Animal cells have vacuoles which are smaller than that of the plant cells.

.Respondent 37 - "It's an animal because I was taught it was".

.Respondent 30 - "It is composed of living cells that aren't classified as plant cells. It breathes oxygen (although not all animals breathe oxygen)".

.Respondent 1 - "It has a backbone".

.Respondent 24 - "It's an animal because it's furry". While this may be true for some animals, it does not distinguish the animal group, neither is it appliable to all animals.

Some of the instances of animals were not classified as animals. Four respondents did not see snail as an animal.

.Respondent 5 - "Phylum Mollusca, it is soft inside, has an external protective covering, can move, arthropod".

.Respondent 8 - "Cold blooded, multi cellular".

.Respondent 19 - "Not as complex as animals. Has simple basic structures for survival".

.Respondent 37 - "Class Gastropoda".

Four respondents did not see grasshopper as an animal.

.Respondent 5 - "Arthropod, internal muscles, external skeleton".

.Respondent 8 - "It's an insect.

.Respondent 19 - "Because of simple structure, do not have circulatory system, digestive system, etc.".

.Respondent 24 - "It is an insect, has an exoskeleton".

Four respondents did not see fly as an animal.

.Respondent 5 - "It's an insect, arthropod, external skeleton, internal muscles".

.Respondent 8 - "Insect, living, multicellular, simple structure, respires, circulatory system, small creature, different category".

.Respondent 24 - "It is an insect, has an exoskeleton".

One respondent did not consider a lizard as an animal.

.Respondent 19 - "No, lizards are not complex".

One respondent did not see a fish as an animal.

.Respondent 19 - "No, because it does not live on land, no limbs, etc.".

Two respondents did not see a worm as an animal.

.Respondent 5 - "No skeleton, it's an arthropod".

.Respondent 9 - "Do you have as complex a system as animals. Has simple structure for survival".

Two respondents did not consider the boy and girl to be animals.

.Respondent 38 - "They are human beings".

.Respondent 19 - "Humans".

A further respondent (number 26) gave a most unconvincing reason: "Boy and girl are animals, teachers say so".

Merely inspecting these examples of responses is enough to suggest that

respondents 5, 8, 19, 24 have most inadequate conceptions of "animal". Among the non-instances, one respondent classified car as an animal.

.Respondent 39 - "A car is an animal when it won't start".

Concept of Living:

In this section there are 8 questions about living. There are two parts to the qeustions : a) requires the respondents to tick yes or no, b) requires the respondents to give reasons/list attributes of living. The instances are spider, fish, bird, tree, boy; the non-instances are bicycle, fire, car. In this case the scientific view of living would include: respiration, nutrition, excretion, growth, reproduction and response to stimula, DNA, genetic material. With the exception of one respondent (19) who saw fire as living, ("Yes, but not long, can be dead soon"), all the others classified the instances correctly. A total of 71% were consistent in using at least some of the above attributes of living. The remaining 29% listed some attributes which are characteristics of plants or animals but are not common to the two, e.g., movement, nervous system.

Concept of Friction:

Two situations are given which explore the concept of friction. The first involves a person on a slide. Respondents consider whether friction is present when the person is sliding at a steady speed, speeding up, or stationary. Comparisons of friction in each case are also asked for. In the second situation a ball is dropped vertically and without spin onto concrete from different heights, and respondents consider the friction between ball and concrete.

Only one of the respondents was consistent in having a scientific view of friction in all situations. Conceptions which were revealed included: no friction present when the person speeds up on the slide (12%), no friction when the person is stationary (34%), friction different for the constant speed and stationary circumstances on the slide (86%), friction is present between the ball and the concrete in the second situation (70%).

Concept of Electric Current

There are four questions about electric current. Question 1 is about a torch with three batteries. Respondents have to consider the relative magnitudes of the current in the three batteries. Question 2 asks about the existence or non-existence of electric current in an empty light socket. Question 3 explores ideas of the magnitude and

direction of electric current in a simple D.C. circuit. Question 4 asks about the existence or otherwise of electric current in a charged battery which is not in a circuit.

All but two respondents (i.e., 95%) answered the torch question correctly. However, 31% believed that a current existed in a bare light socket - over half of these suggesting the "if you put a bulb in there it will glow". Fourteen percent said there is a current in the charged battery which is not in a circuit, while 83% said no. Most of this latter group saw the battery as a source of potential energy.

."No, there is the potential for the current to be produced when a circuit is completed".

."No, because there is no current flowing, the circuit is not completed".

Three students (7%) chose the correct answer but gave no indication of seeing the battery as a source of potential energy.

Concept of Gravity

Three situations are presented (standing on the moon, standing on the earth, falling from a plane), and for each the question "Is there any gravity?" is asked. For the moon and falling questions, the magnitude of any gravity is to be compared with gravity at the earth's surface. Only one student answered the first two questions incorrectly. However, 21% suggested much less gravity when falling, as compared with the earth's surface, and 7% suggested much more.

Summary

Forty two trainee science teachers responded to a science concept test derived from the work of the 'Learning in Science Project'. The following table presents the percentage of those who are judged to have a scientific view of five of the nine concepts tested.

Animal	Living	Force	Gravity	Electric current
26%	71%	30%	66%	40%

CONCLUSION

The basic assumption underlying this study is that science teachers have misconceptions in some selected science concepts. The overall conclusion which can be drawn is that, although the responses were not consistent across the concepts or within the concepts, there are indeed misconceptions. The result is evidence that the graduate trainee teachers have misconceptions in science. The results show that the view of science held by this group of trainee teachers is sometimes little better than the view of science held by students investigated by Osborne et al. The test appears appropriate for use with science teachers.

What do these results imply? They suggest that science teachers may have concepts which are little better than the students they teach. If that is the case, then, is it reasonable to urge teachers to probe their students' concepts before teaching them? Should science educators then redirect their efforts in conceptual change to changing teachers' views before changing students' views?

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Research in Science Education, 1985, 15.

THE EFFECTS OF TRAINING IN CONCEPT MAPPING ON STUDENT ACHIEVEMENT IN TRADITIONAL CLASSROOM TESTS

Kym Fraser and John Edwards

INTRODUCTION

Concept mapping (Novak, 1981) continues to receive increasing attention from science education researchers. It is now also included in most preservice training programs for science teachers at both primary and secondary levels in Australia. However, many of the questions asked by classroom teachers about concept mapping do not relate to the research questions commonly addressed. This piece of action research aimed to look at one of those teacher questions:

"Will training in the use of concept mapping techniques significantly change student achievement in traditional classroom tests?"

While not denying that the widespread usage of concept mapping may in time lead to significant changes in pedagogy and assessment, it is transferability such as this which is of immediate concern to classroom teachers.

RESEARCH DESIGN

Teachers frequently regard educational researchers as "ivory tower" people who possess little insight into the needs of teachers and the realities of the classroom. Two of the concerns in this study were that the research be of potential practical value to the classroom teacher and that it interfere as little as possible with the everyday life of the classroom.

Tisher et al (1972) state that empirical research

'is that which involves the collection of data in specifically designed situations.

These situations may be naturalistic settings such as existing classrooms or tightly controlled, specifically created research situations, or a slight modification of these two alternative'. (p. 217).

Even within the naturalistic settings of the classroom, empirical research may tap into a range of situations along a continuum between the extremes of a contrived and a real-life situation. It must be recognised that introduction into the classroom of research in any form will modify the real-life situation. There are however, degrees of this modification.

Allowing for the concerns expressed above involved a number of compromises in research design particularly in the areas of sample student selection and test design.

Setting

The study involved instruction in concept mapping for twenty-seven Grade 9 science students in a small co-educational independent school in North Queensland. The students were drawn from two classes totalling sixty-three students. The sample students chosen were low and medium achievers as revealed by classroom tests.

During each of three month-long work units groups of four students from each class were instructed in, and carried out the techniques of concept mapping through both class and homework. Sample students' test placings before and after treatment were then compared.

Sample Student Selection

Students in the two classes worked in self-chosen pairs. These pairs were maintained in the study to interfere as little as possible with the normal classroom conditions and to take advantage of the stability afforded by these working relationships. In order to compare pre and post treatment test placings, at least one student in each pair had to show relatively consistent test placings. Criterion for consistency was: "no more than a spread of six placings between pretreatment tests. Each student was allowed one 'inconsistent' test placing. Without this compromise only three students in the sections of the classes from which the sample was drawn could be classified as consistent. This compromise was considered reasonable in view of the writer's experience that students commonly produce atypical test scores."

Low achievers were those students who consistently placed within the last twelve

placings while medium achievers consistently placed between tenth and twentieth. The top students in the classes were not included in the sample as it was considered more realistic to focus the limited resources on areas where significant shifts would be more easily detected.

Treatment

The treatment phase consisted of two sections. The first was a forty-five minute basic instruction session and the second constituted the four week period during which the students produced concept maps and received remediation in the technique.

(a) Overview of instruction

Step 1 Illustration of the key characteristics of a concept map using diagrams which were familiar to the student: a food web and a classification key.

Step 2 Comparison of a concept map and the written paragraph from which it was developed.

Step 3 Reiteration of the characteristics from (1), this time using the concept map from (2).

Step 4 Written format of steps to produce a concept map.

Step 5 Each student produce a concept map.

Step 6 Discussion and correction of the concept maps completed in (5).

(b) Concept map construction incorporated into the classroom routine

After instruction in concept map construction, students were required to incorporate the construction of concept maps into the usual classroom/homework routine. During this period, student concept maps were corrected for errors in mapping techniques, logic, misconceptions, and for the possible incorporation of more information. The following situations allowed sample and non-sample students to work from the same information but in different ways:

(i) Given a set of terms, write a paragraph (draw a map) incorporating those terms.

(ii) Define (draw a map of) a set of terms.

(iii) Read and summarise a section of the text. (Read a section of the text, select key words and develop a map).

(iv) Given a heading, select relevant terms and write a summary (draw a map) using those terms.

During non-teacher-centred lessons, in which students worked independently, teacher contact with treatement and non-treatment groups was kept equivalent. The teacher carried a special roll and placed a t beside each student's name each time interaction with the teacher occurred. Use of this monitoring device allowed interaction with students to be equalised.

Throughout the year students sat for end-of-unit tests. These tests were the usual content/process based tests which were normally used with this grade level. The tests were based upon tests used in previous years and were developed in collaboration with the Head of the Science Department at the School, a usual procedure in the School. It is important to remember at this point that the concept mapping technique was being evaluated for its value in the system which commonly operated in the school. Therefore the tests were not specifically designed to elucidate concept mapping effects.

Scores on the total number of unit tests given prior to each treatment were used to establish an estimate of each individual's expected level of achievement. This baseline information was compared with the test result for the treatment unit. Since each of the unit tests covered different content, had a different level of difficulty and had slightly different numbers of items, all test results converted to Z-scores.

To provide a more stable estimate of baseline performance, Z-scores for the baseline data prior to intervention were averaged to obtain a mean predicted Z-score ($\bar{X}_Z$). A comparison of the mean predicted Z-score with the Z-score obtained from the treatment (X_Z) was used to evaluate whether there had been a significant change in a student's achievement.

To evaluate the significance of the differences obtained, the standard error of

measurement (SE_m) was calculated for $\bar{X}_Z$ and X_Z. The SE_m for each $\bar{X}_Z$ was calculated by averaging the SE_m of the tests used to calculate $\bar{X}_Z$. Differences between $\bar{X}_Z$ and X_Z were judged to be significant if the difference between the scores was greater than the confidence limits set around each score by its SE_m. Gronlund (1976) used the same criterion to determine significance. However, in his study, he compared an individual's test results by recording test performance in the form of bands which extended one SE_m above and below the student's obtained scores. When the two bands overlapped the test performance was assumed not to differ significantly.

Student mastery of concept mapping was assessed by the teacher/researcher according to the correct ordering, and then correct relating of concepts, the truth value of positions, and the explanatory power and clarity of propositions. Each student was given an overall mastery rating of high, medium or low.

RESULTS AND DISCUSSION

Tables 1 and 2 contain Z-score data for a number of the students in the study.

Six of the twenty-seven students showed statistically significant improvement in the end-of-unit test after the treatment, one student showed a significant negative change and the other twenty students showed no statistically significant change. A student who was treated twice showed significant improvement on both occasions. There were eight significant results.

Twelve of the twenty-seven treatment students had end-of-unit testing data from other units after their treatment unit. Of those twelve:

(i) four showed a marked decrease in Z-scores on these units compared with their treatment unit Z-scores.

(ii) eight students produced Z-scores on these units which were similar to their treatment Z-scores.

Only three students (L.G., P.W., and H.R.), who made significant improvement after treatment, did subsequent tests allowing assessment of longevity of effects. In all three cases results fell back to pre-treatement levels. In this respect, the significant improvement of P.W. on re-treatment is encouraging and suggests the value of longer training and continued reinforcement.

TABLE 1

SAMPLE STUDENT END-OF-UNIT ACHIEVEMENT

Class	Student	Test					
		1	2	3	4	5	6
III_1	C.B.	-0.88	-0.25	-1.11	-0.64	-0.94	-1.46
	L.G.	-1.13	-0.49	0.06	-0.23	-0.27	-0.08
	C.V.	-0.20	0.94	-0.06	-0.12	0.10	-0.30
	P.W.	-0.30	-1.13	0.43	-1.06	-0.34	0.47
	H.R.	-1.80	-2.60	-1.73	-0.95	absent	-1.85
	A.N.	0.14	-0.25	0.74	-0.33	-0.34	0.28
	K.G.	-1.72	-1.13	-2.16	-1.89	-3.12	-3.20
	G.M.	0.56	-0.17	0.00	0.50	0.03	0.57
	M.R.	-0.88	-0.02	-0.12	-0.33	-0.57	0.66
	A.R.	-0.62	-0.80	-0.80	-1.89	0.05	-0.49
	J.W.	0.05	-0.25	1.22	0.29	0.33	0.28
	B.P.	-0.11	0.14	-0.06	-0.23	-1.09	0.47

__ underlining represents membership of the treatment group for that unit.

TABLE 2

BASELINE AND INTERVENTION END-OF-UNIT ACHIEVEMENT TEST z-SCORES

Class	Student	Achievement Rating	Mapping Mastery	Baseline Test Scores		Treatment Test Scores		Significance
				$\bar{X}_z$	SE_m	$\bar{X}_z$	SE_m	
III_1	C.B.	L	L	-0.57	0.49	-1.11	0.36	NS
	L.G.	L	H	-0.81	0.49	0.06	0.36	+
	C.V.	M	L	0.37	0.49	-0.06	0.36	NS
	P.W.	M	H	-0.58	0.49	0.43	0.36	+
	H.R.	L	H	-2.04	0.45	-0.95	0.54	+
	A.N.	M	M	0.21	0.45	-0.33	0.54	NS
	K.G.	L	M	-1.67	0.45	-1.89	0.54	NS
	G.M.	M	H	0.50	0.45	0.50	0.54	NS
	M.R.	L	H	-0.34	0.47	0.66	0.55	+
	A.R.	L	M	-1.03	0.47	-0.49	0.55	NS
	J.W.	M	L	-0.33	0.47	0.28	0.55	NS
	B.P.	M	M	-0.07	0.47	0.47	0.55	NS

H - high
M - medium
L - low

Of the twenty-seven students, eleven were rated with high concept mapping mastery, six were rated medium, and ten were rated low. The following were revealed when a comparison was made of student achievement and concept mastery:

1 the one medium and five low achievers who showed statistically significant positive changes in Z-scores all showed a high level of concept mapping mastery,

2 one low and four medium achievers also showed high concept mapping mastery but no significant change in treatment Z-scores,

3 four medium and two low achievers rated as having medium concept mapping mastery but showed no significant change in Z-scores, and

4 six medium and four low achievers rated as having low concept mapping mastery. One of the low achievers showed a significant negative change in Z-scores while the others showed no significant change in Z-scores.

Both low and medium achievers showed an ability to master and apply concept mapping techniques. This is in accordance with Novak's (1981) findings.

In this study the one-shot intervention treatment was not sufficient to allow the development of a high level of concept mapping mastery by over half of the students. Although only twenty-two percent of the sample students produced significantly improved results, the tests were not specifically designed to detect concept mapping effects and less than fifty percent of the students showed high concept mapping mastery. The goal of the exercise was to isolate any significant change in achievement on normal classroom tests, when instruction was supplemented with concept mapping. For certain students in this particular classroom context, classroom test achievement improved significantly when they were trained in concept mapping and used throughout the unit.

CONCLUSIONS

Due to the small numbers, this study should be viewed as an illuminative pilot study. The main points arising are:

. students who did not achieve a high level of concept mapping mastery showed no significant improvement in performance on normal classroom end-of-unit achievement tests.

. over half of the students who achieved a high level of concept mapping mastery also showed a significant improvement in performance on normal classroom end-of-unit achievement tests, and,

. concept mapping should be incorporated into the ongoing classroom instruction patterns if performance gains are to be maintained.

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NEGOTIATING AN AUSTRALIAN GENERAL SCIENCE. THE PROFESSIONAL DILEMMA 1939-45

Rod Fawns

THE GARDENERS AND THE ENGINEERS

A close study of the papers and letters of pioneers like Roy Stanhope reveal an active interest in the historical context of science education in Australia. One paper Roy has retained was an address presented to a meeting of the New Education Fellowship in 1944 by Eric Ashby. They were secretary and president respectively of the STA, NSW in 1939-40.

Ashby arrived in Sydney in 1938, the same year that John Turner arrived in Melbourne: both from England to Chairs of Botany. Ashby was a gifted public speaker who on his return to England described himself as a travelling salesman for science. Widely, travelled, and broadly educated, he, more eloquently than others was able to proclaim and demonstrate the potential of science as a public resource - both as a badge of utility and the key to good citizenship. These ideas were to be reflected in the history of general science in Australia.

In his N.E.F. address Ashby proposed that school science be taught as a non-vocational subject to demonstrate the great social achievements of science and the scientific method. This remains a highly radical proposition. The type of text he suggested was Hogben's Science for the Citizen. Ashby, like Stanhope in this respect, made historical analyses serve his social purpose.

By 1944, as Chairman of the Professorial Board, The Australian National Research Council and of the Scientific Liaison Committee set up by the Curtain Government to mobilize scientific manpower for the war effort, Ashby was in a stronger position than most to attack narrow scientific schooling by likening it to shop-keeping. A lack of

public recognition and authority was a highly sensitive issue amongst the scientists and science teachers of this period (King 1968).

Ashby said he was out to break academic glass. On the one hand he deplored the "shrunken ambit" of the university professors who set the Leaving Syllabi in NSW: some of whom he suspected were "about as familiar with school children as I am with the various species of beetle". On the other he attacked the laissez-faire view, held by a few superannuated liberals, that the teacher should not presuppose any particular kind of society, and education. This, he said, assumes that the final and exclusive purpose of education was the fostering of the free development of personality through the unhampered unfolding of innate qualities.

The laissez-faire view he felt had been made untenable by the discoveries of modern ecology and genetics. The Nazi view of education as a political instrument he rejected on moral grounds and he proposed "a middle ground" a Labor platform for Social Reconstruction.

The papers Ashby wrote whilst in Australia show that he saw himself as part of a movement to promote and extend the application of science for the welfare of society and to protect and advance the status of the scientific profession, especially in those sciences not covered by existing professional organisations. Ashby and fellow biologists founded the Australian Association of Scientific Workers in each state modelled on the radical British movement inspired by figures like Gregory and Bernal.

The membership of the AASW included teachers, as well as academics interested in the development of the social and biological sciences. With the publication of the Australian Journal of Science from Sydney from 1939 the Associations in various states were able to signal their engagement in social planning particularly in public education about Science.

Ashby had sought with some success to seek direct representation of the AASW on all major scientific advisory committees. In the war years he had pulled scientists closer to the political inside. In 1945 Ashby was sent, on the initiative of Evatt, to Moscow as a counsellor to the Australian legation (Ashby, 1947). But this success was short-lived. As the war menace declined Ashby's advocacy of social planning had exposed division in the scientific community. McCarthyist attacks in parliament on the AASW were associated with its demise (Buckley-Moral 1982).

Ashby returned to England in 1946 finally to Clare College, Cambridge and a Peerage. In the preface to a retrospective collection of his Australian "pamphlets: Challenge to Education, Ashby (1946) offered this bitter comment of the reassertion of entrenched conservative influences in Australian society.

> "In Australia it is extremely important that the tradition of academic freedom should be preserved, and that advantage should be taken of it; for the opportunities for political and sectarian interference in education are greater here than in other British countries; and the customs of the Public Service do not encourage criticism from within the Service. Those who are free to talk should talk freely."

If Ashby was a social engineer, John Turner was a gardener.

Turner remained at Melbourne University to become a key figure in the emergence of the Australian conservation movement, and achieved eminence as the author of the Royal Commission Report on the Sydney Sparkes Orr case into academic freedom in the University of Tasmania.

No less important but certainly less recognised was Turner's cultivation of a science for all and a prominent place for biology in school science. He chaired the General Science and Biology Standing Committees of the University's Schools Board from their inception in the war for 25 and 30 years respectively. His successor as Chairman of the General Science Committee was Peter Fensham. In two periods in which he was the Dean of Science at Melbourne University important changes occurred. In 1944 General Science replaced a series of specialised courses up to Year 10 in Victoria, and in 1963 the Academy of Science undertook the sponsorship of the B.S.C.S. adaptation which he had initiated in Victoria.

During this whole period he says he never saw a science lesson and entered a school laboratory only once - after hours. He retained a conviction, based on his deep respect for one of his own schoolmasters in particular and also collaborating teachers like Fred Daniel and David Morgan, of the major influence for good of science teachers.

For Turner the definition of General Science diplomatically framed in the 1935 Report on General Science to the Science Masters' Association was a useful tool:

> "General Science is a course of scientific study and investigation which has its roots in the common experience of children and does not exclude any of the fundamental special sciences. It seeks to elucidate the general principles observable in nature, without emphasizing the traditional division into specialized subjects until such time as this is warranted." (Lauwerys et al 1935).

Gone are Ashby's social history and clear thinking. Introduced is a sense of the child's natural environment.

Records of Turner's papers and letters in the University of Melbourne Archives, and his oral accounts, show how his confidence was also sustained by a sense of community with the Cambridge Botany circle whose influence and liberal ideals extended to four states at this time. Prominent Cambridge liberals from Samuel Wadham and John Medley (1945) were important influences on the young Turner's reformist writing in the war years. Also important for its persistent support to Turner was A.C.E.R. A.C.E.R. was an important conduit for American progressivism in Australia (Cunningham, 1938a). As early as 1938 it had reported favourably to Browne and Wadham of the Schools Board on the value of extending its General Science Courses to year 10 (Wadham, 1938b). Wadham wore many hats.

Textbook authorship was consistent with the academic gardening of liberal reform in schools. In the preface to his General Science text General Science for Australian Schools, Turner put his finger on the essential tension in General Science "we have tried to provide a course which, although it is "general" in touching everyday life at many points, is still "science" in that it emphasises fundamental principles."

Turner made his commitment to social knowledge of a biological kind in General Science as Chairman of the inaugural meeting of the Victorian Branch of the A.A.S.W.

THE RESISTANCE TO A GENERAL SCIENCE

The resistance to a General Science in the forties came predominantly from private school teachers and physical scientists who saw no unifying principle in the social purposes of its advocates. The denial related firstly to a marked scepticism about the scientific status of teacher explanation in biology. Teacher explanations were assumed to have no existence at all apart from the scientific phenomena which were assumed to express themselves. As unobserved events the non-physical explanatory thoughts of teachers were not valued. This academic distinction between thought proper and immediate experience of the physics demonstration on the one hand and acquaintance theories of knowledge attached to advocacy of general science on the other, are very familiar to us.

The physical scientists were often sceptical about the scientific status of biological explanations and methods. The academic arguments were put at the Conference to the new Science Teachers Association of Western Australia by Professor Ross, its physicist patron in 1944. The following year Stanhope was the key speaker at the same conference. At this time he was a school teacher at Murwillumbah and his air fare was paid by A.C.E.R. His advocacy of the pragmatic, progressive, economic and social value of general science teaching was fully reported in the Perth papers and on radio (Stanhope 1945). The Australian Journal of Science published only the Ross (1945) address.

> "I have already pointed out that explanations of biological phenomena are essentially physical or chemical. Hence we cannot unduly cut down physics or chemistry if our science teaching is to be more than a collection of more or less unrelated and unexplained observational facts. Again, biological phenomena are more difficult to study and less useful in teaching scientific method to young people because the phenomena are more complex and we have less control over variable factors."

The fundamental academic principles were being reasserted over everday life.

> "Physics, both from the fundamental importance of physical qualities and from the ease of control in its experiments, must remain the basis of elementary training in science and in science method."

He concluded by laying down the professional conditions of acceptance of General Science. Biology or self knowledge Ross argued should be included in school science curriculum only after due consideration of the following points -

> "(a) In extending the course to include physics, chemistry and biology science must be allocated at least the time of a double subject;
> (b) Biology does not lend itself so readily to training in scientific methods as do the physical sciences;
> (c) With broadening the field to be covered the difficulty of obtaining suitable science teachers increases."

Turner was highly sensitive to such criticism but had found that their negotiation would require diplomacy and persistence - both resources in short supply. He worked on each of these issues from within the University and Schools Board at different times over the next 20 years.

The social and pedagogical arguments of Stanhope, Turner and Ashby were overshadowed by the reassertion of "academic" or institutional arguments after the war. We recognise this without any great sense of oddity in the General Science

textbooks of the post-war period. Biological knowledge was smuggled in but the social relations of science left at the classroom door. Turner acknowledged the defeat in the preface to his text.

> "Some may criticize this partial sacrifice of theoretical ideals to classroom realities — The ultimate ideal is the evolution of a General Science Course arranged in units around central topics, where the unifying principle is the social relations of science. But we must learn to walk before we run and we believe that the present course will provide most schools with a sufficiently big step in the right direction." (Turner 1945).

The subsequent eclipse of Daniel's and Turner's (1943) narrative or storytelling text by Pfitzner and Heading's (1946) and James and Rowney's (1954) "logical" anthologies supports Turner's assessment. Turner felt the narrative quality of his text was assisted by the application of an editorial rule of thumb that a scientific term which did not appear more than six times in a draft chapter should be excised.

The big step that Turner felt he had achieved in the text was a well-written account of science suitable for all students. What he had to demonstrate to teachers was that Biology could be reduced to teachable form and to make it compulsory. He had shown that it was academically sound at one level by securing the university's adoption and at another by providing a text, that academic teachers could use. In the process of establishing Biology in schools he found that he had to establish the academic respectability of general science, work out what it could be at this level and how to examine it. Here the experienced Daniel was very important in Turner's gardening. He realized it was general science which would have to adapt to schools rather than schools adapt to general science. Twenty years later he felt he was in a position to tackle the unfinished pedagogical reforms in the Web of Life.

RESEARCH ISSUES

The study of writings, letters and correspondence of pioneering figures in science education such as John Turner in Victoria and Roy Stanhope in NSW allows a study of the protracted process of negotiation and action in the securing of curriculum change. By pursuing an understanding of the complexity of curriculum action and negotiation over time we may well establish a meaningful sequence through which to test and formuate theory. In the conflict over general science for example three main hypotheses could be examined:

(a) That the dominance of "academicism" in school science and other subjects can be related to the professional aspirations of teachers and academic scientists. That established subjects are not fixed entities but shifting amalgamations of sub-groups of teachers and scientists carry the message of social change into schools (Waring, 1978; Fensham, 1977).

(b) That in the process of establishing general science as a school subject arguments moved from promoting pedagogical and social issues to academic continuity in the school and university. Boundaries and priority changes in courses can be seen to be a consequence of attempts to redefine "tradition" or the past of science and education (Layton, 1984; Jenkins, 1980; Goodson, 1982).

(c) That internal conflict over the boundaries and priorities of school science has divided and weakened any potential challenge posed to the traditional forms of the grammar school curriculum by the public interest in the impact of science and the challenge to values which often accompany these achievements (Darling, 1938; Fawns, 1982; Layton, 1974).

The question raised earlier of the reliance that should be placed upon 'interpretation' as against 'events' is important in researching the process of practical negotiation of curriculum change. How much weight for example is to be ascribed to the explanatory thought of the agent gathered as oral history in interviews and personal correspondence and how much to actions recorded in public documents of various types?

Moreover actions leading to reform of textbooks, syllabi and examination papers have "inside" and "outside" properties. There are properties which can be known only to agents. There will be other properties arising from the public effects of these changes which suggest the action can be assessed only from the outside. Research into motives and purposes seem to require attention to both properties of the action.

Sometimes at least the researcher rather than the agent provide an account that lies closer to the truth. Turner was, for instance, surprised by the possibility suggested by the author that Ashby had destroyed any prospect Stanhope and Dakin may have had of science for all in NSW in the forties by his attack on General Science.

Ashby observed that most general science courses surrender all the advantages of a study of separate sciences and keep all the drawbacks. They are supposed to be related whenever possible to the experiences of everyday life, but this is not their underlying theme. The theme is still professional science: a wider and more scrappy anthology than ever.

The criticism was characteristically accurate but too late to change events in the Schools' Boards in Victoria and Tasmania, however. One prominent private school

spokesman, Michael Simmons, quoted Ashby when criticizing a pamphlet "Making A Living on the North Coast More Effectively Through Science Teaching", that Stanhope had sent him for comment:

> "You in my opinion lay too much stress on what Ashby calls the "intellectual Woolworth" approach—" (Simmons 1944).

Here Ashby was quoted by upholders of the narrow vocationalism he sought to replace. By 1946 Ashby was arguing that the general science movement was imitative and dependent, rather than aflame with faith and free.

> "With the naive enthusiasm of a faddist taking a new patent medicine, some Australian Departments of Education have adopted General Science as an examinable school subject. This is not the outcome of careful planning of the place of science in secondary education. It is a reflex action to the haemorrhage (especially from America) of attractive textbooks in general science. I hope that I might have deflected New South Wales from following the fashion. My theme is that you should define your purpose in teaching science at all in schools before you draw up the syllabus." (Ashby, 1946).

Accurate to the point of worrying Turner 40 years later, this statement reflects Ashby's frustrated hopes for science education as a cultural enterprise.

It would be a perfectly respectable historical enquiry to seek the authentic Turner or Ashby or Stanhope by attempting to reconstruct their war years, to re-enact their experiences or rethink their thoughts. Methodological insight could be found in authorities such as Collingwood (1946) Marwick (1970) and Dray (1980). But historiographical studies do not have to serve history nor do we have to "raid" archives of science education for a snapshot to "prove" a contemporary theory of social structure. To understand the influene of material forces on the form and content of school science requires an understanding of the symbolic integration of these material effects in what Oakshott (1983) called "the flow of sympathy, the current of social activity". We can enquire into the practical past of science education in order to understand the social context of contemporary curriculum negotiations.

It is not that we stand on the past to see the future. Rather the present is composed of these arguments which are recognised to have survived from near or distant past, ready to be recalled from where they lie in present discussion to be noticed, enjoyed or employed for what they may be made to mean or for whatever they may be identified with in respect of current practice.

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PREDICTING TERTIARY ACADEMIC PERFORMANCE IN TERMS OF STUDENT COGNITIVE AND NON-COGNITIVE VARIABLES

Howard Fearn-Wannan

INTRODUCTION

Early attempts to predict tertiary academic performance (i.e. to build an appropriate theory of performance) proved to be extremely frustrating for many workers around the world. This frustration was expressed in Anderson's (1972) statement that "accounting for academic performance is like trying to nail red-currant jelly to a well."

In modern times researchers no longer look for individual cognitive predictors of academic performance but rather take a multivariate approach, including cognitive and non-cognitive student parameters as well as contextual parameters in their attempt "to nail that jelly to the wall."

This research project has followed the latter approach and, using curvilinear multiple regression analysis, has produced a quantified hypothesis about academic performance in higher education. This study set out to test the hypothesis on two recent populations of first-year students at the Royal Melbourne Institute of Technology.

THEORETICAL FRAMEWORK

As far back as 1935, Lewin expressed the view that human behaviour is a function of characteristics of the person and the characteristics of the person's operating context. His field theory was interpreted by Murray (1938) in terms of student needs, and an environment which serves to satisfy or frustrate these needs. Since the time of

Lewin and Murray, many investigators such as Kelly (1966) have made efforts to view human behaviour from this transactional perspective.

Because of the limitation of resources and time, the present author's earlier work (e.g. Fearn-Wannan, 1979, 1981) considered the student in terms of his cognitive characteristics and his academic self-concept only. Little effort has been put so far into a study of contextual variables. The criterion variables were classified as mediating variables (e.g. Test Anxiety), or as ultimate outcomes (e.g. Academic performance). The variables were set up in the form of causal models which attempted to show the logical interrelationships amongst their components.

Despite the considerable effort that was put into this research project up to 1982, the early models seemed incapable of accounting for more than 25% of the corrected variance in academic performance, even though large arrays of explanatory variables had been considered.

Early impressions given in the literature relating to academic performance implied that intellectual differences amongst the highly selected students in higher education were minimal and were unlikely to be useful predictors. Accordingly most of the author's research effort had been directed toward the non-cognitive aspects of the student's make-up as sources of variance in performance.

However some interesting work by Juraschek (1975), Prosser (1977) and others has pointed to the higher Piagetian categories of thinking (e.g. evaluation ability) as a fruitful source of explanatory variables. This has been confirmed, and such variables included in the model.

THE VARIABLES

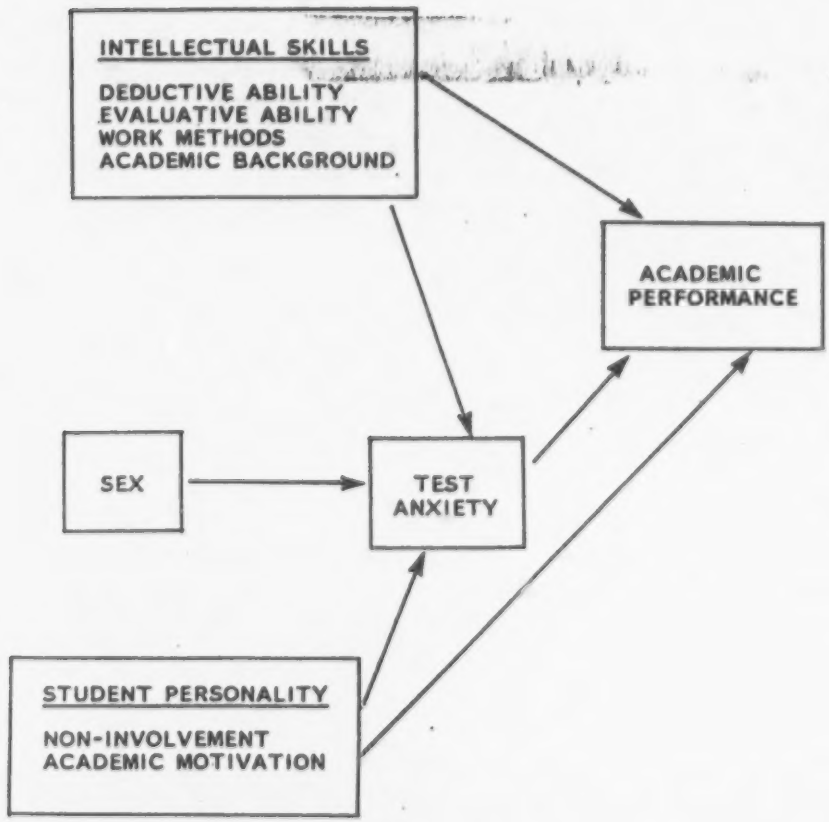
In earlier studies by the author, 28 different explanatory variables have been investigated. Many of these have given significant correlations with academic performance. Nevertheless the following eight predictors only have been chosen because they have consistently appeared as meaningful (i.e. explaining at least 1.5% of the criterion variance each) explanatory variables in earlier studies:

SEX	SX	1.80%
ACHIEVEMENT MOTIVATION	AM	4.29%
NON-INVOLVEMENT	NI	3.15%

TEST ANXIETY	TA	0.76%
BACKGROUND KNOWLEDGE	BG	6.53%
WORK METHODS	WM	15.23%
DEDUCTIVE ABILITY	DA	2.12%
EVALUATIVE ABILITY	EA	2.44%

The criterion variable in all studies has been academic performance. The subjects in which academic performance has been assessed have been Biology and Chemistry.

FIGURE 1 CAUSAL MODEL OF ACADEMIC PERFORMANCE IN HIGHER EDUCATION



In this paper, no attempt has been made to demonstrate the validity of the causal model which is implicit in this study (see Figure 1).

RESEARCH PROCEDURE

1. A causal model of the relationships between the criterion variable (i.e. academic performance in first-year Biology) and an array of explanatory variables were derived for the 1983 class of students (N = 146) at the Royal Melbourne Institute of Technology (See Figure 1).

TABLE 1

MEASURES OF PREDICTION ACCURACY FOR TWO INDEPENDENT POPULATIONS OF FIRST-YEAR STUDENTS AT ROYAL MELBOURNE INSTITUTE OF TECHNOLOGY (1984)

POPULATION	PERCENTAGE OF PREDICTED MARKS WHICH LIE WITHIN		
	5 marks of attained mark	6-10 marks of attained mark	11-20 marks of attained mark
1984 APPLIED BIOLOGY (N=107) (BIOLOGY)	43 (0.84)	36 (0.74)	21 (0.74)
1984 MEDICAL LABORATORY SCIENCE (N=45) CHEMISTRY	52 (0.94)	25 (0.84)	23 (0.58)
MEAN PREDICTIVE VALIDITY	(0.89)	(0.79)	(0.66)

(Note* : reliabilities are given in parentheses)

For two independent populations every student's mark has been forecast within 20 marks of the actually attained mark with a large majority of the predictions being within 10 marks of the attained mark (See Table 1)

2. The B-coefficients of a curvilinear multiple regression equation (involving linear, square and interative terms) were computed using stepwise regression analysis. A multiple regression equation suitable for the computation of the predicted scores of the 1984 population was thus constructed. (See next section).

3. The mathematical model so derived was used to predict the academic performance of the 1984 population of first-year students of Biology (N = 107) and of Chemistry (N = 45) at the Institute.

4. A comparison was made between the predicted and the attained academic performance.

The hypothesis

That an array of cognitive and non-cognitive characteristics of first-year students largely determines their academic performance.

DISCUSSION

Good prediction of the academic performance in Biology has been achieved for the first-year students using the curvilinear regression model derived from the 1983 first-year student population. About 43% of the students had their marks in Biology accurately forecast to within 5 marks of the attained marks, and another 36% being forecast to within 6 to 10 marks of the attained mark. (See Table 1). The mean predictive validity index was 0.79.

Similarly for the 1984 Medical Laboratory Science student population (criterion subject - Chemistry) the same equation gave very satisfactory predictions, 52% being within 5 marks of the attained mark, and another 25% being within 6 to 10 marks of the attained mark. The mean predictive validity index in this case was again relatively high at 0.79.

It is obvious that a small proportion of these student populations (i.e. those whose predictions deviate quite widely from the attained marks) are being influenced by factors as yet unidentified. One suggestion has been that diet might be a determinant of academic performance.

CONCLUSION

The ability to achieve such good predictions suggests that there are subject-independent replicable endemic relationships amongst the variables in question. Further successful attempts at prediction across populations of Biology students, across disciplines, and across types of institutions of higher education would further strengthen the validity of this hypothesis underlying academic performance in higher education.

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THE ANALYSIS OF SCIENCE CURRICULA IN AUSTRALIA

Malcolm Rosier

INTRODUCTION

The aim of the Second International Science Study (SISS) is to provide a comprehensive picture of science education across the world. The study is being conducted under the auspices of the International Association for the Evaluation of Educational Achievement (IEA). There are 26 currently countries (educational systems) participating in the study.

The Second International Science Study is not simply a study of science achievement. Certainly science achievement is being assessed, but in the context of the way in which science education is conducted in the participating systems. This context includes the structure of the education system, with particular attention to the percentage of young persons in the population who are attending the different stages of education, and the extent to which they are studying science. The context also includes the nature and content of the science curriculum.

STAGES OF THE CURRICULUM

For the purpose of the study the curriculum is regarded as having three sequential stages. The first stage is the "intended curriculum". In most systems this is defined at the level of the authority in charge of education, which may be the country as a whole in a highly centralized system (such as Japan), or an individual school board in a decentralized system (such as the US). At some stages of education in some countries (as in some States in Australia) the curriculum may only be defined at the level of the individual school or even the individual teacher.

The second stage in the sequence is the "translated curriculum", which has its

locus at the level of the individual classroom. It is the task of the individual teacher to translate the intended curriculum into set of learning experiences which the teacher deems to be appropriate for the particular group of students in the class.

The final stage of the curriculum sequence is the "achieved curriculum". This refers to the extent to which individual students have internalized the curriculum experiences that were planned and organized for them. That is, the achieved curriculum indicates how much scientific knowledge the students have learnt.

The Measurement of the Intended Curriculum

There are three reasons for commencing the study with the measurement of the intended curriculum. The first reason for the curriculum analysis is to provide a description of the science curriculum across the world at a given point in time.

The second reason for the curriculum analysis is to assist in the development of the international science tests to be administered to the sample students. From the initial set of curriculum ratings supplied by the participating systems it was possible to identify the main areas of curriculum content common to the majority of the systems. This ranking of content areas was used in the selection of science test items to be included in the trial test program, and subsequently, after review, in the final set of international instruments.

The final reason for conducting the curriculum analysis is to gather information to assist in the explanation of differences that may be observed in the science achievement as measured by the SISS tests. It is a key element of the study that comparisons of science achievement across systems should take account of the different curricular experiences of the students in the different systems.

Content Dimension

The science study uses a classification system for the description of the content of science curricula. The content dimension has 57 categories. It is similar to the one in the first study, and is based on work by Klopfer, subsequently reported in more detail in Klopfer (1975). There are four sections in the classification, reflecting the traditional areas of Earth Science, Biology, Chemistry and Physics.

It was recognised that these traditional areas may not adequately reflect science curricula that attempted to relate students' learning experiences in science to their

practical experience in their own town or village. Ad additional set of categories was therefore developed to cover areas like Rural Science and Health Science. This paper does not cover these other science content areas, or the process dimension that was also measured.

The analysis of curricula was carried out by assigning numerical ratings to the content areas according to the following pattern:

Rating 3	the content area has a high level of coverage, being taught with major emphasis to all or most of the students following the curriculum
Rating 2	taught with medium level of coverage
Rating 1	taught with low level of coverage
Rating 0	not included in the curriculum

In Australia, where decisions about curricula are rather decentralized, it was necessary to conduct a survey of schools in order to determine the curriculum being used. The responses were then collated to give an overall rating for the system.

SURVEY PROCEDURES

The results presented here are based on the survey of science curricula in schools across Australia. A pilot survey was conducted in 1983. The survey of the content dimension was conducted in the second half of 1983. The survey of the content dimension was conducted in the second half of 1984 using a large number of schools.

Population 1 in Australia is an age-defined population: 10-year-old students in Years 4, 5 and 6. The sample used for the curriculum survey consisted of the schools in all Australian States that took part in the science testing program. In each of these schools the teachers of science were asked to assign ratings for the science curriculum covered by the Year 5 students. For each State the mean of the ratings at each year level was then calculated. Finally, an Australian weighted mean was calculated based on the percentage of Year 5 students in each of the States. A similar process was followed to obtain ratings for students in Year 9 and Year 10 from the schools in the Population 2 sample.

TABLE 1

MEAN CURRICULA RATINGS ACROSS YEAR LEVELS:
EARTH SCIENCE AND BIOLOGY

Science Content Area	Year 5	Year 9	Year 10	Year 12 Earth	Year 12 Biol.	Year 12 Chem.	Year 12 Physics
Earth Science							
1 Solar System	2.1	1.8	1.4	1.3			
2 Stellar Systems	1.6	1.4	1.2	1.1			
3 Meteorology	2.2	1.8	1.2	0.5			
4 Constitution of the Earth	1.8	1.7	2.0	2.5			
5 Physical Geography	1.3	2.0	2.0	2.1			
6 Soil Sciences	1.3	1.1	0.9	1.1			
Means Earth Science	1.7	1.6	1.5	1.4			
Biology							
7 Cell Structure & Function	0.5	2.4	2.1		3.0		
8 Transport of Cellular Material		1.4	1.3		2.6		
9 Cell Metabolism		2.2	1.9		2.5		
10 Cell Response		1.1	1.4		1.8		
11 Concept of the Gene		0.3	2.4		2.3		
12 Diversity of Life	2.0	2.1	1.8		2.7		
13 Metabolism of the Organism	1.6	2.3	2.1		2.7		
14 Regulation of the Organism		1.1	1.1		2.7		
15 Co-ordination/Behaviour of the Organism	1.4	1.0	1.5		2.3		
16 Reproduction and Development of Plants	1.5	1.9	1.8		2.4		
17 Reproduction and Development of Animals	1.7	2.0	2.3		2.7		
18 Human Biology	2.2	2.4	2.3		2.9		
19 Natural Environment	2.3	1.8	1.8		2.6		
20 Cycles in Nature	2.2	1.8	1.6		2.4		
21 Natural Groups and Their Segregation					2.1		
22 Population Genetics					2.4		
23 Evolution		0.5	1.8		2.6		
Means Biology	1.7	1.6	1.8		2.5		
Number of Schools	181	192	191	38	136	132	133

TABLE 2

MEAN CURRICULUM RATINGS ACROSS YEAR LEVELS: CHEMISTRY AND PHYSICS

Science Content Area	Year 5	Year 9	Year 10	Year 12 Earth	Year 12 Biol.	Year 12 Chem.	Year 12 Physics
24 Introductory Chemistry	1.0	2.7	2.5			2.9	
25 Electro-Chemistry		1.0	1.7			2.8	
26 Chemical Laws		0.9	1.6			2.9	
27 Chemical Processes		1.8	1.8			1.9	
28 Periodic System		1.4	2.0			2.8	
29 Energy Relationships in Chemical Systems		0.8	0.9			2.2	
30 Rate of Reactions		0.8	0.9			2.2	
31 Chemical Equilibrium						2.9	
32 Chemistry in Industry	0.9	0.9	1.5			1.8	
33 Chemical Structure		2.1	2.4			2.7	
34 Descriptive Inorganic Chemistry	0.2	1.5	1.9			2.4	
35 Organic Chemistry	0.7	0.7	1.7			2.5	
36 Environmental Chemistry		1.4	1.7			1.4	
37 Chemistry of Life Processes		1.3	1.4			1.2	
38 Nuclear Chemistry		0.4	1.3			1.4	
Means Chemistry	0.7	1.3	1.7			2.3	
Physics							
39 Measurement	2.7	2.1	2.1				2.7
40 Time and Movement	2.6	1.0	2.4				2.9
41 Forces	1.5	1.7	2.2				2.8
42 Dynamics		0.8	2.1				3.0
43aEnergy	1.6	1.8	2.3				2.9
43bMachines	1.4	1.4	1.4				0.8
44 Mechanics of Fluids	1.6	1.1	1.0				0.3
45 Introductory Heat	1.9	2.1	1.5				1.1
46 Change of State	1.7	2.0	1.5				1.0
47 Kinetic Theory	0.5	2.1	1.6				1.6
48 Light	1.3	1.8	1.9				2.0
49 Vibrations and Sound	1.9	1.5	1.4				2.4
50 Wave Phenomena							2.9
51 Spectra	1.2	1.1	1.5				2.5
52 Static Electricity	1.1	2.0	1.8				2.9
53 Current Electricity	1.5	1.8	2.1				2.9
54 Eletromagnetism/ Alternating Currents	1.9	1.6	1.7				2.8
55 Electronics		0.2	0.7				1.3
56 Mpecular & Nuclear Physics	0.1	0.3	1.2				2.3
57 Theoretical Physics	1.4	1.5	1.7				2.1
Number of Schools	181	192	191	38	135	132	133

The Year 10 curriculum ratings are being used as an indicator of the minimum curriculum covered by all students at the Year 12 (Population 3) level. Year 10 is the last year level in Australia at which virtually all students in Australia are following a general science curriculum involving elements of Earth Science, Biology, Chemistry and Physics. It is assumed that all students at Year 12, whether or not they are currently studying science, will have covered the science curriculum as represented by the Year 10 ratings. Of course, the students taking science subjects in Years 11 and 12 will have covered more science content in particular aspects of the curriculum.

At Year 12 there was a series of specialist populations for students taking Earth Science, Biology, Chemistry and Physics (Population 3E, 3B, 3C and 3P). The curriculum ratings for these populations were sought from the schools across Australia in which the specialists tests were administered.

SUMMARY RESULTS

The mean content ratings across the seven populations are shown in Tables 1 and 2. The ratings are weighted means, which will always be mainly influenced by the results for the larger States of New South Wales and Victoria. The ratings are given to one decimal place.

In examining the ratings for Populations 2 and 3 it is important to remember that, for any students in Australia, this is the last opportunity for them to study science before dropping the subject or leaving school. One of the reasons given for including science in the school curriculum is that it will help the students to become more responsible citizens in a society which is becoming rather complex and technological. It follows that areas of science not covered in school by the end of Years 9 and 10 will probably be missing from the experience of many of the young persons entering the wider society outside the school.

The first group of content categories in Table 1 refers to Earth Science. The ratings for Year 12 are not reliable, being based on a relatively small number of schools. This is in itself an indication of the low coverage of Earth Science at the upper secondary level.

The main areas covered by the Year 5 level are Solar System and Meteorology

(Categories 1 and 3). Across all populations there is a low coverage of Soil Science (Category 6). For the Biology section of Table 1 there are some blanks for Year 5. No ratings were obtained for these categories, since it was considered unlikely that the topics would be covered by many students at this level.

In Biology, the main areas covered at Year 5 are Human Biology, Natural Environment and Cycles in Nature (Categories 18-20). Most of the topics at Year 12 receive high mean ratings, as is appropriate for the systematic study of Biology at this level. It may also be noted that there is a rapid increase of coverage from Year 9 to Year 12 in the topics of Concept of the Gene and Evolution (Categories 11 and 23).

The first part of Table 2 deals with Chemistry. There is little coverage of Chemistry at Year 5, even in the descriptive areas. At this level Chemistry in Industry (Category 32) refers to "raw materials and their uses", Descriptive Inorganic Chemistry (Category 34) refers to "properties of simple elements and compounds" and Organic Chemistry (Category 35) refers to "petroleum, coal and natural gas". It appears that students at this level are receiving only a weak introduction to basic chemical ideas.

Even at Years 9 and 10 there is little coverage of Chemistry apart from Introductory Chemistry (Category 24) and Chemical Structure (Category 33). The Chemistry students at Year 12 appear to have a high level of coverage of the traditional topic areas, but a low coverage of more applied areas such as Chemistry in Industry (Category 32) or Environmental Chemistry (Category 36).

The ratings for Physics show only a medium level of coverage for most topics at Years 5, 9 and 10. At Year 12 the Physics students have a high level of coverage of the traditional ares, but a much lower coverage of more applied areas, such as Machines (Category 43b) and Electronics (Category 55).

When the ratings in Tables 1 and 2 are looked at as a whole, the common feature at the Year 5, Year 9 and Year 10 levels is the low coverage of content areas across all parts of this classification of science curricula. The results show little evidence of an explicit or implicit core curriculum in science that is conducted in the majority of schools across Australia.

The ratings show that the students at this Year 12 level are undertaking more systematic studies of the respective disciplines of Biology, Chemistry and Physics. The

ratings for Chemistry and Physics suggest that there is a major focus on the theoretical aspects of the subjects, with less attention to practical or applied topics. This observation suggests the need to investigate whether the students graduating from these courses have practical skills and knowledge relevant to the needs of employers who are attempting to up-date the technological component of their industries.

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KLOPFER, L.E. Evaluation of Learning in Science. In Bloom, B.S., Hastings, J.T. & Madaus, G.F. Handbook on Formative and Summative Evaluation of Student Learning. New York, McGraw-Hill, 1975. pp. 559-641.

Research in Science Education, 1985, 15.

RESEARCH NOTES

In addition to the reports which appear in the preceding pages there were other presentations at the conference about research in progress, aspects of data collection, and speculations about future studies in science education. The following notes have been complied so that R.I.S.E. readers will become acquainted with other significant matters that were discussed during the annual conference.

1. Assessing the quality of learning outcomes by Gloria Dall'Alba

   Traditionally in science classrooms, the assessment of learning has been primarily concerned with the quantity of knowledge that is recalled. More recently researchers have expressed the need to focus on the quality of the learning outcome. But how can the quality of learning outcomes be assessed? This presentation addressed that question and considered a way of defining learning outcomes, an operational definition of the quality of learning outcomes, and difficulties in measuring the quality of learning outcomes. The presentation was essentially a report of research in progress, and included several extracts from transcripts taken from interviews with students in years 8 and 9. The investigator pointed out that an operational definition of the quality of learning outcomes should incorporate the dimensions of extent, precision, accord with reality or generally accepted truth, ratio of internal to external associations, complexity, and relevance to the task. It was also noted that the difficulties in measuring the quality of learning outcomes were due to the multi-factorial nature of quality, and to variation in the relative importance of the quality dimensions on the same task and between tasks.

2. Probing students' understanding of environment concepts using visual stimuli by Barbara Johnson and Peter Fensham

   In this presentation the techniques of using visual stimuli in the form of photographs, to investigate students' understanding of, and interest in the environment, were presented. Students in years 7, 9 and 11 at two neighbourng High Schools and students in year 5 of three feeder Primary Schools were asked one question for each of three different sets of six photographs. The questions were:

   a) Which two of these six environments would you like to be in?

   b) These six photographs each show environmental problems. Select any two and name the problem shown.

c) These photographs show different environmental issues. If you could select your science course for the rest of the year, which two would you like to learn about, and why?

As a consequence of their research the investigators concluded that the presentation of photographs of environmental situations to the groups of students produced a surprisingly common set of responses. They found that for each of the tasks one or two of the environmental situations were preferred as choices, and these preferences tended to be the same for at least years 7, 9 and 11 and for two of the tasks at year 5 also. There was also little evidence of significant shifts in the strength of these preferences with age (year 7 to 11). The investigators stated that the existence of such clear preferences, at least for students in a common social milieu, and the ease with which this methodology revealed them, are both of interest. It immediately becomes obvious to ask how widespread are such common preferences. Would they extend throughout a large metropolitan city like Melbourne, or would western and eastern surburban students respond differently? Further research of this sort could answer such questions.

3. Teachers as researchers in primary science: The use of the clinical mode by P. Lynch, B. Jones, C. Avery, P. Blackaby, L. Hurburgh & R. Matthyoz

This presentation described the attempts of a group of primary science teachers to implement a clinical method or mode to provide a basis for subsequent teaching of scienc topics in class. The presentation outlined the stages followed to reach decisions about classroom teaching. First, there was a Piagetian type, clinical interview of selected primary school students to explore their understandings of nature of matter. Data from the interviews allowed concept maps to be constructed. Second, a multiple choice questionnaire (with a short free response section) was administered to obtain more detail about pupils' understandings. Finally, from the insights gained from the first two stages teaching sequences and approaches were selected for a series of lessons. For instance, Grade 2 lessons were designed to be almost entirely oral with some drawings, while Grade 3 lessons required pupils to make written responses on large sheets of paper. The responses were decoded by the teacher during discussion. The teachers involved in the exercise indicated they were pleased with the results, and that there were shifts in their thinking about the meaning and importance of the concepts being taught and about the teaching processes.

4. Children's uderstanding of inheritance by Marjory Martin and Judith Kinnear

This presentation reported a study to investigate children's understanding of inheritance. A sample of grade 6 children (N = 84) from three different schools was used and data were collected using pencil and paper tasks on aspects of

inheritance and computer simulations for pairs of children to identify rules that govern the inheritance of coat colour, pattern and tail length in a familiar domestic animal. It was noted that children recognise the existence of many rules relating to inheritance but, in some cases, have alternative concepts based on observations outside a genetics context.

5. Enquiry teaching in the chemistry laboratory by Raymond Nadeau and Marshall Nay

This session described an action research study to determine the extent to which students were able to attain enquiry objectives while performing specially designed enquiry oriented chemistry experiments. The subjective meanings and feelings that students had regarding this type of learning were also investigated.

The laboratory programme was conducted with a grade 12 chemistry class during an entire semester. Behavioural objectives in the conceptual, affective and scientific skill domains were measured by means of two paradigms - the empirical analytic, and the situational interpretive. The instruments used to gather data for the evaluations included a chemistry achievement examination, processes of science test, test on scientific attitudes, laboratory questionnaires, students' written comments, taped interviews, laboratory reports and teacher's log.

Although students in this study spent considerably more time in laboratory related activities than did students in conventional chemistry teaching, they performed very well on the achievement test. In pre- and post-testing, they showed significant gain on the process skill test but not on the test of scientific attitudes. A significant majority of students found the laboratory programme not only challenging, interesting and enjoyable, but also felt that the enquiry experiments were preferable to the highly structured experiments performed in previous years. The investigators concluded that the research results showed that enquiry oriented learning and teaching is viable in high school chemistry.

6. The learning environment of a school developed science program for poor readers by Steve Ritchie

This presentation reported some initial results from a comprehensive evaluation of a school developed program to provide alternative science instruction for poor readers in normal classes. A number of procedures were used to gather comprehensive data for the evaluation, e.g. observations of lessons, interviews with students and staff, and the administration of an environment questionnaire, namely the "My Class Inventory". This learning environment inventory was modified to cater more adequately for both staff and student responses by using a four-point response format. The data obtained using the inventory and other techniques were interpreted as providing a comparable picture of the learning

environment. For instance the mean scale scores obtained for staff (N = 5) and students (N = 23) on all scales were of the order of 17.5 or greater. These scores were interpreted to indicate that the Year 8 science bridging program provided a pleasant and productive learning environment. As well, these data and that obtained through the other procedures, were interpreted as indicating that generally the intended science bridging program curriculum had been implemented. Data from the interviews and observations also indicated that many students finished the required activities earlier than expected, and teachers rarely found opportunities in the classroom to interact with the science bridging program students. As a consequence other recommendations for change were proposed.

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The following requirements have been established to facilitate editing and maintain standards in format and presentation.

GENERAL LAY-OUT AND LENGTH

Setting out: The paper (including diagrams, tables, etc.) is to be typed on A4 sized paper, using double-spacing with wide margins - at least 2.5 cms on the left and 1.4 cms on the right. (Note that these margins are to be left on all pages, including those containing tables, diagrams, etc.)

Length: The total length of any one paper must not exceed twelve A4 double-spaced typed pages (this length includes text of the paper, reference lists, and all diagrams, figures, and tables).

Figures: Camera-ready copies must be supplied with the paper.

Headings: Main headings (central and in capitals) and sub-headings (underlined and left-justified) should be used at reasonable intervals to aid in the reader's comprehension of the text. All pages should be numbered consecutively.

FOOTNOTES AND REFERENCES

Footnotes: These should not be used although Reference Notes, e.g., Smith (Note 1) may be used to refer to unpublished material. The reference notes are to be collated at the end of the paper, e.g.,

Note 1, J.J. Smith, personal communication

Note 2, R.E. Jones, 'Myths about science teaching', paper presented at the Regional Directors' Conference, Darwin, May, 1980.

References: References to journals and books should follow the criteria of the A.P.A.

In the general text of the paper references should appear as Bernstein (1971) or Fisher and Fraser (1983), then these references should be placed in the reference list as,

BERNSTEIN, B. (1971). Class, codes and control. London, Routledge & Kegan Paul.

FISHER, D.L., & FRASER, B.J. (1983). A comparison of actual and preferred classroom environments as perceived by science teachers and students. Journal of Research in Science Teaching, 20, 55-61.

* Please note the order of dates, volume number, publisher, place of publication for books and journals, use of upper- and lower-case letters.